PUBLIC HEALTH.

ELEVENTH REPORT

OF

THE MEDICAL OFFICER OF THE PRIVY COUNCIL.

WITH

APPENDIX.

1868.

Presented pursuant to Act of Parliament.

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1869.

TO THE LORDS OF HER MAJESTY'S MOST HONORABLE PRIVY COUNCIL.

My Lords,

In obedience to the Public Health Act, 1858, I have the honour of herewith submitting to Your Lordships, for presentation to Parliament, my Report of the proceedings which Your Lordships under that Act directed to be taken during the year 1868. And for the present purpose I treat as part of that subject-matter the proceedings which Your Lordships directed to be taken under the Vaccination Act, 1867.

I am, my Lords,
Your Lordships' obedient servant,
JOHN SIMON.

Medical Department of the Council Office,
8, Richmond Terrace, S.W.,
March 31st, 1869.

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MEDICAL OFFICER'S REPORT.

I.—VACCINATION.

New Vaccination Law.

The superintendence of Public Vaccination in England occupied during the whole of the year 1868 a more than ordinary share of the attention of the Lords of the Council. For on the first day of the year the new Vaccination Act, 30 & 31 Vict. c. 84, came into operation; and, from then onwards, my Lords were constantly engaged in proceedings, such as the Legislature intended to be taken, for the improvement of our public vaccination in respects where the system had hitherto been at fault.

New regulations affecting contracts.

The nature of the defects which required correction had been very fully explained in successive annual reports of this department, particularly in those from the second to the sixth inclusive; and as far back as 1859 my Lords had communicated to the Poor Law Board, for the assistance of local authorities contracting for public vaccination, an exposition of the broad principles of arrangement on which contracts must in future be based if the defects in question were to be prevented. In 1868, with the new law, the time had come when this merely recommendatory mode of dealing with very serious evils could no longer be considered sufficient; and my Lords accordingly saw fit to issue express regulations for the purpose, by an Order of Council bearing date February 18th, 1868. Of the regulations thus issued, a copy is subjoined to this Report, as Appendix No. 2. The great object was that public vaccination should no longer be so excessively subdivided among times and places and persons as to have needless difficulties put in the way of its effective performance; and with this object the regulations provided, as their general effect, that the public vaccinator under ordinary circumstances should vaccinate only at public stations, and at no station oftener than once a week, and, if in a town district, only at one station therein; that no two public vaccinators should in any case act for one and the same district; and that the division of towns into vaccination districts should not go beyond certain limits of smallness. Also, with reference to section eight of the new Act, a special regulation was made, limiting the extent to which re-vaccination at the public expense might be given.

New contracts.

The new law did not abrogate any of the existing contracts for public vaccination, but it tended to make new contracts in many cases desirable; and thus during the year new arrangements, which had to be conformed to the new law and to the regulations operating under it, and which my Lords had to consider in more or less detail, and for the most part very minutely, with the respective local authorities or with the Poor Law Board, were proposed by more than a seventh part of the entire number of

vaccination authorities of the country. The year has in this way been one of very great improvement in our system of public vaccination. Also in other and ordinary ways influences for improvement have been at work.

Ordinary inspections, and awards to vaccinators.

The systematic inspection which goes on under their Lordships' orders extended during the year to nearly half the public vaccination of England, namely, to 1,749 vaccination districts, comprised in 312 different unions or parishes: each inspection involving, first, an inquiry into the state of vaccination in the district; secondly, where requisite, a notification to the authority of defects found in the local arrangements for carrying the law into effect, and advice as to the changes required; and thirdly, in suitable cases, a recommendation of the vaccinator for reward under section five of the Vaccination Act, and in accordance with the system described in my ninth report. Of the money which Parliament had placed at their Lordships' disposal for this purpose my Lords distributed 2,753*l.* 2*s.* The number of vaccinators to whom gratuities were given was 345; namely, 129 who received first-class, and 216 who received second-class, gratuities. The gratuities of each class differed of course very considerably in money value in different vaccination-districts, just as the several contract-earnings differed. Where a public vaccinator was having so few vaccinations as to be only earning from his board of guardians some 20*s.* or 30*s.* a year, the supplementary payment by the Privy Council was necessarily quite insignificant as money, and, except that it implied an honorable recognition of service, might scarcely have seemed worth the trouble of formal transmission and acknowledgment; but, on the other hand, in many cases the payments were such as probably to be in themselves welcome additions to the often scanty stipends of the recipients. The largest aggregate payment of the year (a first-class gratuity on 2,738 vaccinations) was 136*l.* 18*s.*; the smallest (a first-class gratuity on 19 vaccinations) was only 19*s.*

Outbreaks of small-pox.

My Lords during the year had occasion to correspond specially with the guardians of the unions of Congleton, Enfield, Epping, Sheffield, Tendring, Tiverton, and Totnes, with regard to outbreaks of small-pox reported in those jurisdictions respectively.

Supply of vaccine lymph.

The applications made to this department during the year for vaccine lymph were 14,099; in answer to which were supplied as follows:—131,390 charged ivory points, 1,059 charged squares of glass, and 9,792 charged capillary tubes. Particulars as to the sources whence this lymph was derived are given in Appendix No. 1. Of the 14,099 applications, in answer to which lymph was given, 11,085 came from medical practitioners (including 1,462 poor-law medical officers) in England and Wales; 1,721 from Ireland, and 511 from Scotland; 566 from the army; 73 from the navy and emigration department; 101 from colonies, and 42 from diplomatic and other foreign services. My Lords, as usual, took means during the year to satisfy themselves as to the undiminished efficiency of the lymph which is supplied under their directions.

With reference to this branch of the service, my Lords had their attention drawn to a system which is in vogue in some parts of the continent, for maintaining continuous sources of lymph-supply for the human subject by keeping a succession of calves inoculated with the specific contagium; and their Lordships had a report prepared for them by Dr. Ballard on the arrangements which are in use abroad for this so-called "animal vaccination." Further information, however, is requisite before any final opinion can be formed on the question of making more or less use of the system for purposes of our National Vaccine Establishment; and therefore on the present occasion the subject cannot be written of in detail.

MEDICAL OFFICER'S REPORT.

Animal vaccination.

Fourteen of the twenty-two stations which are sources of lymph-supply for the National Vaccine Establishment, and also two stations which do not supply lymph for the public service, are used as educational stations under their Lordships' Order of December 1st, 1859. My Lords during the year inquired as usual into the conduct of the educational business of these stations, and received on this subject, as on the subject of the lymph-supply, a report which was entirely satisfactory.

Educational status.

II.—General Sanitary Administration.

During 1868, as usual, in various cases within purview of the general sanitary laws of the country, my Lords had to communicate with the respective local authorities concerning action to be taken under those laws. The authorities thus communicated with were 50; including 14 of the special boards of the metropolis, 5 extra-metropolitan vestries, 15 boards under the Public Health and Local Government Acts, and 16 boards of guardians. In seven of the cases, local inquiry by an inspector under their Lordships' direction was deemed necessary, viz., at Walton-le-Dale in Lancashire, at Bootle in the same county, at Thetford in Norfolk, at Clifton-Hampden in Berkshire, at Barnet in Middlesex, at Luton in Bedfordshire, and at Dunstable in the same county.

Occasional sanitary inquiries.

In the systematic sanitary inquiries which my Lords have for ten past years been carrying on, as to the distribution of disease in England and the circumstances by which it is regulated, there was in 1868 an almost complete pause; owing in some measure to the fact that the working power of the department was accidentally for the while much reduced; and in other part, because with the present commencing second decennium of sanitary responsibility, a new cycle of work had to be begun, and a great deal of consideration had to be given to questions of improvement of system.

Systematic sanitary inquiries.

The department has, however, been indebted to Dr. Ballard, medical officer of health of the parish of Islington, for a very interesting voluntary contribution to knowledge, in the form of a report on the statistics of sickness treated at the public expense in Islington during the last 12 years; and this report by Dr. Ballard is subjoined. See App. No. 3.

Sickness treated at public expense.

The only respect in which my Lords in 1868 extended their previous series of systematic inquiries as to the distribution and circumstances of disease, was an inquiry concerning the prevalence

Venereal diseases in London.

of venereal maladies among the poorer parts of the civil population in London; and for this inquiry Mr. Wagstaffe, one of their Lordships' inspectors, collected some detailed information which is given in his subjoined report. See App. No. 4.

III.—Auxiliary Scientific Investigations.

Pathological investigations.

The pathological work of the department was continued during 1868 in both of the directions to which I referred in my last yearly volume; and details of this work are given by Dr. Sanderson and Dr. Thudichum in their respective subjoined reports. See App. Nos. 5 and 6. Dr. Sanderson, continuing from the previous year the very important investigation of tubercular disease, has now succeeded in throwing new light upon a large part of that subject-matter; and Dr. Thudichum, in the chemical field of research, has made considerable further progress in continuation of the line of 1867.

IV.—Additions to Sanitary Law.

Pharmacy Act, 1868.

An important addition to the sanitary law of the country was made last year by the passing of the Pharmacy Act, 1868. This statute is chiefly directed against evils to which I particularly drew attention in my sixth report, as attaching to the practice of pharmacy by unqualified persons, and to the too unrestricted procurability of poison for criminal purposes. The new law is to be worked by the Pharmaceutical Society, under the general sanction and supervision of my Lords of the Privy Council. It provides that in future no one shall begin any such pharmaceutical practice as involves a sale of poisons, unless he have first passed a sufficient examination in pharmaceutical knowledge; and that poisons shall not be purchaseable except with such personal identification as would probably hamper anyone who intended to make criminal use of them; and that the keeping and sale of poisons generally shall be subject to regulation under the Act. It also affirms an important principle in regard of the adulteration of drugs, by enacting that the provisions of the Adulteration of Food Act of 1860 shall be extended, mutatis mutandis, to the sale of drugs.

V.—Question of State Interference to provide for the Disinfection of Prostitutes.

Proposals to extend the operation of the Contagious Diseases Act, 1866.

The inquiry of the department into the prevalence of venereal diseases among the civil population was intended to contribute some of the elements necessary for judging a question which of late has been much agitated before the public: the question, *whether it is expedient to have in this country a systematic sanitary superintendence of prostitutes.* During the last few years, under the provisions of special Acts of Parliament—the so-called "Contagious Diseases Acts" of 1864 and 1866, a system of this sort has been administered on a small scale, by the War Office and Admiralty, at certain military and naval stations; and recently,

while these departments have been proposing to extend their own operations with respect to the two public services which they direct, the more general question has been raised by the advocacy of a voluntary association formed for the purpose of promoting the extension of the Contagious Diseases Act, 1866, to the civil population of the United Kingdom.

Special case of Army and Navy, as distinguished from that of Civil Population.

There are here two questions which I think cannot be too strictly distinguished: the question concerning the army and navy, and the question concerning the civil population. It has not been any part of my duty to advise on the former of these questions; and I now only advert to it for the sake of greater clearness in proceeding to discuss the other. It seems to me that prostitution and its attendant diseases, in their relation to the army and navy, are, in two different points of view, matter of public concern and responsibility; first, because the military and naval services at their respective stations are essential determining causes of prostitution, and the State, which for its own purposes keeps those masses of male population unmarried, cannot claim to be indifferent to the result; and, secondly, because the specific diseases which arise in that mode of life occasion so enormous a quantity of temporary disablement in the two services as to be of pecuniary importance to the entire tax-paying community. These I apprehend are the grounds on which rests all that has yet been done by the Legislature with reference to venereal diseases: grounds which are in the utmost degree exceptional as regards the nature of the case: and to argue from such a case to the case of the civil population would manifestly be a confusion of judgment. Of the venereal diseases of the civil population, English sanitary law has not hitherto taken any special cognizance; and whether this neutral state of the law ought or ought not to be abandoned is a separate question, of far more intricacy than seems to be generally imagined, and which on all accounts certainly deserves most careful consideration.

Requirements involved in proposal concerning civil population.

In proceeding to discuss this question, I may conveniently first refer to the programme of the association which I have mentioned—the "Association for promoting the Extension of the Contagious Diseases Act, 1866, to the Civil Population of the United Kingdom." The Association contends "that sufferers under any kind of [venereal] contagious disease are dangerous members of society, and should, so long as they are in this state, be prevented from communicating it to others; . . that common prostitutes should be subject to a compulsory medical examination, and to compulsory detention in hospital as often as they are found diseased, and as long as they continue so; . . that, for the reception of prostitutes suffering from venereal disease, hospital accommodation should be provided in all towns where such persons congregate."* To give a notion of the quantity of hospital accommodation which would be requisite to satisfy this programme, I may observe, for instance, that London is conjectured

* Report of Association, sections 2, 33, 32.

to have some 18,000 women whose living is gained by prostitution;* and that, according to one of the secretaries of the society, on any given number of prostitutes, always about one-third may be assumed to be diseased.† If, instead of insisting on these colossal estimates, we take only half their total result, the plan would require for London alone the creation and maintenance of new hospital accommodation nearly equal to that which is now given by the twelve general hospitals of London for all bodily diseases put together: accommodation, namely, for 3,000 patients. The charge of maintaining (independently of the cost of constructing) such lazarets as the above would probably be at least 100,000*l.* per annum: and their construction would probably represent a first cost little short of half a million of money: besides all which there would be the considerable annual charges for police arrangements and medical inspections. This for London alone! And the requirements of other large towns would probably be of like proportions.

And how, and by whom, to be met? and on what grounds?

Demands like the above are evidently not likely to be met by voluntary contributions. The result, if to be got at all, can only be got under action of law; and any such law, whether empowering the central government to defray expenses out of proceeds of general taxation, or empowering municipalities to assign local funds for the purpose, is, of course, in relation to minorities, compulsory. Now, it is quite certain that, rightly or wrongly, the proposed appropriation of money would, in the eyes of very large numbers of persons, be to the last degree odious and immoral. In most municipal constituencies there are swarms of persons who already find it no easy matter to satisfy the collectors of rates and taxes; they would see the prostitute kept in hospital at their expense for weeks or months, not necessarily from the exigencies of severe illness of her own, but essentially that she might be made clean for hire, lest any of her users should catch disease from her; they would remember in contrast, that for themselves wonderfully little is done by authority to protect them against adulterations of food, or against false weights or measures; and they might regard it as a strange caprice of law which should oblige them to contribute to the cost of giving an artificial security to their neighbour's looseness of life. It seems to me very important to measure beforehand the degree in which such arguments would be valid, or rather to consider on what principles (if any) the proposed intervention of law is to be justified.

Primâ facie, venereal diseases are not any concern of Government;

I suppose it may be assumed that public policy is very decidedly in favour of marriage as against promiscuous fornication; that the latter, however powerless may be laws to prevent it, is, at least, an order of things which no State would willingly foster; that, whereas it has some inherent inconveniences, among which is the liability to specific contagious maladies, such drawbacks from its attractions are not in their kind a matter for general social regret;

* Appendix of Assoc. Report, p. 22.
† Mr. Curgenven, on the Contagious Diseases Act of 1866, p. 7.

that venereal diseases are, in principle, infections which a man contracts at his own option, and against which he cannot in any degree claim to be protected by action of others—the less so, of course, as his option is exercised in modes of life contrary to the common good; that thus, primâ facie, the true policy of Government is to regard the prevention of venereal diseases as matter of exclusively private concern. *Caveat emptor!* And though it must be admitted that to some extent the consequences of promiscuous fornication spread beyond the persons of the original performers; the infections of the brothel being oftentimes carried into simultaneous or subsequent wedlock, and in some cases fixing their obscene brand even on the offspring of such marriages; this horrid fact is only one of many which might be cited, where innocent wives and children participate more or less severely in consequences which husbands and fathers have earned. To be wife or child of a drunkard or a gambler involves evils against which the State does not affect to give security; and, primâ facie, the dependent interest must be equally unprotected by the State against harms which that other sort of looseness may bring on it.

but this with qualification.

I am very far from thinking that the above are the sole considerations to which regard must be had in deciding such questions as the present. But they seem to me to define a position which ought not to be abandoned, except under strong compulsion of circumstances, and with reasonable prospects of success. Evidently, if venereal diseases were now the same gigantic scourge and terror which they were some 350 years ago, when they inspired Fracastoro's poem, and if curative medicine had continued as powerless against them as then: if we saw them still raging as great intractable epidemics, impeding national movements, and forcibly occupying the mind of society with all sorts of lazarous presentations: the reasons for legislative action, *provided such action could be effectual,* might be stronger than the reasons for neutrality, and considerations as to the personal ætiology of the disease might perforce have to be subordinated to the urgency of a public danger.

Medical grounds on which the proposal has to be judged:

The cardinal questions, then, are two:—First, does the detriment which venereal infections cause to the public health reach those limits at which principles generally preferable ought to be exceptionally abandoned by the State? Secondly, would the good which can be got through State interference in this matter be enough to reasonably compensate for the cost at which it would have to be attained? I must confess that I cannot with any approach to confidence answer either of these questions affirmatively. As regards the first of them, I have not the least disposition to deny that venereal affections constitute a real and great evil for the community; though I suspect that very exaggerated opinions are current as to their diffusion and malignity; but since the resources of curative medicine against them are constantly becoming stronger and stronger, it seems probable that the worst of them will year by year become less and less important (as endangering life or limb) in cases where infection may obtain. It may also be anticipated

that the greatly improved knowledge which late years have given to the medical profession with regard to the venereal contagia will spread, and not very slowly spread, through the minds of the general public, and will soon very much reduce the number of those sad cases where infected men give syphilis to their wives and offspring. On the other hand, as regards our power of preventing venereal diseases by such a superintendence of prostitution as is proposed, it is certain that no appreciable good would be got except with much organization, and at very large cost of money; and there are strong reasons for believing that the gain so purchased would, on analysis, be found to belong very predominantly to those kinds of venereal disease in which the community has little or no permanent interest.

what is the magnitude of the mischief?

First, as regards the actual quantity of venereal disease current in this country, and the importance of such disease to the public health, it is to be remembered that under the head of "venereal diseases" are included three chief sorts of disease, and of course in each sort many different degrees of severity. The three sorts to which I refer, and which in any given person are not incompatible with one another, are gonorrhœa, pseudo-syphilis, and true syphilis. *Gonorrhœa* is never even temporarily of much importance to women, nor ever, unless very exceptionally, of much permanent importance even to men; but yet thus far it is not a quite unimportant infection, that in men it is often extremely inconvenient, indeed sometimes involves for a time painful and even disabling complications, and cannot absolutely be said never to leave permanent local damage behind it. *Pseudo-Syphilis*, or so called "simple chancre," is a form of ulcer which may be of considerable local destructiveness, and is often attended by inguinal buboes, but leads to no specific ulterior consequences. *True Syphilis*, arising as "hard chancre," or in other less characteristic primary affections, involves an outbreak or successive outbreaks of so-called "secondary symptoms;" which, though almost invariably amenable to medical treatment as they arise, and probably in an immense majority of cases not of more than transient importance to the person attacked, are yet not infrequently a more or less troublesome relapsing illness, and sometimes, even in spite of treatment, a long subsequent danger to life; and this true syphilis is of permanent interest to society, partly because of the cases (though comparatively very few) in which it is intractable in the person of the original sufferer, but still more because of the indefinite duration of time for which he or she may at intervals be capable of infecting others, and because the issue of syphilitic parents is apt to perish during utero-gestation, or to be born more or less syphilitic. In seeking to estimate, without exaggeration, the harm which society suffers from venereal diseases, and the good which preventive measures may possibly effect, it is, of course, essential to observe the distinctions between the above-described three sorts of disease: above all not to use the word "venereal" as if it were synonymous with "syphilitic;" and it is also essential that whatever purports to be statistical evidence on the subject

should be evidence on a sufficiently large and impartial scale. The report of the "Association for Promoting the Extension of the Contagious Diseases Act to the Civil Population" gives some statistics which might lead to an impression that in London from one-fifth to one-third of the sick poor are suffering from "a contagious disease of the gravest character, which is constantly transmitted from parent to offspring;" but the contents of Mr. Wagstaffe's subjoined report (App. No. 4.) satisfy me that no sufficient grounds for any such impression exist: rendering it, I think, highly probable that, of the sick poor who at any given moment are receiving medical relief under the poor law and at dispensaries and general hospitals in London, only about 7 per cent. have venereal disease of one kind or another, and that only in about half this proportion the form of disease is true syphilis. Again, a piece of the experience of the Children's Hospital in Great Ormond Street, as quoted in the report of the Association, may seem to suggest that "about one-fifth" of the sick children of the poor are sick with immediate consequences of inherited syphilis; but on inquiry I find that, of 118,590 children of the poor treated during the last ten years for all sorts of diseases at the Ormond Street Hospital, the proportion recorded to have been syphilitic has been only $1\frac{1}{2}$ per 100. Thus, in both cases the quantity of evil appears to be many times less than advocates of legislative interference may imagine; and it must be remembered that London probably illustrates the utmost dimensions which the evil can attain in this country.

how far is the mischief preventable?

Then, as regards the preventability of venereal diseases, even the abstract question (abstract I mean from considerations of cost) is by no means an easy one. Especially we are in want of exact discriminative information as to the good which other countries have got from their sanitary superintendence of prostitution. I believe it to be the fact that, even under strict systems of police, prostitutes in very large proportions escape the intended supervision; and that in their evasive traffic so large a dissemination of venereal diseases may be kept up as to leave in net result very little apparent success to be boasted of. Let it be assumed, however, that, in any place where circumstances are favourable, "venereal diseases" in mass may be greatly reduced under such a system: but there remains as an unfortunate accident of the case, that this reduction might least of all affect those sorts of disease in which society is incomparably most interested; and in the absence of exact records on this point, expectations ought, I think, to be very moderate. For the various local states which most habitually spread the infection of true syphilis are apt to be in themselves such slight and painless affections as almost or entirely to escape the patient's notice; and indeed in women primary syphilitic ulcers, and other local states capable of infecting with syphilis, not only very often pass unnoticed by the patient herself, but have often been overlooked in examinations made expressly for their discovery. And with reference to proposals that particular inspections of women should take place on the information of men whom they have infected, insuperable difficulties are created in the case

of true syphilis by the very long incubation-time of the primary infection: an interval generally of at least three weeks, and capable apparently of extending to six weeks or more: during which time the inoculated part presents absolutely no sign of infection; and at the end of which time the infected man may (for obvious reasons) be in utter ambiguity as to his infectress.

and with what difficulties? and at what proportionate cost?

When the question of preventing venereal diseases is considered as one of administration and finance, some of the above facts become important difficulties. It is proposed that the organization should take equal cognizance of all sorts of venereal disease: indeed this, if the organization were in existence, would seem practically inevitable; partly because of uncertainties and precariousness of diagnosis; partly because cases, taken in the order of their permanent interest to society, would very often be in inverse order to that which the relative urgency of personal sufferings would dictate. And thus, so far as the extinction of true syphilis is to be deemed the essential object of the system, the organization would in two ways tend to be disproportionately expensive: on the one hand, because expending a very large share of its strength on diseases of no permanent importance to society, and, on the other hand, in such measure as cases of true syphilis would escape the intentions of the system.—Further, when the administrative question is considered, not as national and one, but as distributed among many local authorities, a new sort of difficulty presents itself. Whatever good can be got from a sanitary superintendence of prostitution, if worked with uniform strictness through the entire country, the good will not only of course diminish, but will diminish at an immensely increasing rate of diminution, in proportion as the system is not universal and uniformly strict; so that a local expenditure which would give remunerative results, if other places were acting on the same system, might easily, in the contrary case, appear comparatively unproductive. This has been a chief point in the case of those who have pressed for an extension of the present venereal diseases law; and the Association's report has for one of its chief texts, "Free communication between localities, fatal to success of Act in limited districts."

Practical conclusions:

The broad result in my mind from the various above-stated considerations is that at present I very decidedly refrain from recommending any change in that neutral position which English law has hitherto held in regard of the venereal diseases of the civil population. So far as my present knowledge enables me to judge, I believe that any departure from that position could do little but embarrass and disappoint.

as to compulsory legislation;

That under a well-planned national system, obligatory in its local operation, and stringently directed from the centre, with an enormous establishment of lock hospitals, with prostitution universally submitted to strict methodical supervision by police, and with very frequently recurring minute surgical examination of the persons of prostitutes, a great reduction might be made in the present prevalence of venereal diseases among the civil population; and that as part of such reduction (though probably in comparison

but a small part) there would be a diminution in the prevalence of true syphilis; these are propositions which I do not dispute; but their very important converse has to be remembered, that, in proportion as the above conditions cannot be attained, the hope of results becomes chimerical. The conditions, I need hardly observe, are such as there can be no reasonable present expectation of seeing realized in this country; and I must add that, in the present state of my knowledge, I could not advocate any such legislation as would even approximately fulfil them. Not only do I doubt whether the evil can in any reasonable sense be said to call for the repugnant and very costly measures of prevention which alone could pretend to be of effect against it, but also I feel bound to press for something like proportion in the treatment of such matters. And recognizing how incomplete is hitherto our sanitary system, and particularly how little pressure is yet put on local authorities in matters of far more general importance to life: recognizing, for instance, that it is almost entirely a question of private charity whether fever hospitals exist in a town, and that such hospitals are most insufficiently provided: I cannot but think that during this state of things compulsory legislation in the present matter would be a disproportion not to be justified.

as to giving option to local authorities;

On the other hand I have to observe that the somewhat uncertain amount of good which very strict compulsory legislation might produce would less and less admit of being realized, in proportion as the provisions of law were non-compulsory; and a law, giving to local authorities or populations any considerable scope for option in the present matter would quite unquestionably be futile. Everyone knows how valueless such legislation has been in the greater part of the hitherto province of sanitary law, even as regards objects of foremost necessity to the public health; so valueless, that in all chief respects compulsory legislation has already had to be substituted for it; and the light of those experiences may be applied, mutatis mutandis, to the present extremely difficult and delicate subject matter. There probably would be detailed discussions, often indefinitely prolonged, and resulting in inharmonious conclusions, in innumerable vestries and town-councils and wardmotes; discussions which, if not to bear fruit, ought in the interests of decency to be deprecated; but of action, capable of giving success, there certainly would be little or nothing. It is true that under permissive law there have been exceptional instances of local exertion for other sanitary purposes; but even solitary instances of such exertion could not in the present matter be anticipated; for here the peculiar discouragement would exist, that no town could be sure of satisfactory results from its own superintendence of prostitution unless other towns, in communication with it, were acting upon the same system.

as to legislating for a voluntary system;

In a particular proposal, which I think it my duty to mention, permissive legislation, of a sort which would almost entirely rest on a system of voluntary contributions, has been contemplated;

and this proposal was received last year with some favour by the Committee of the House of Lords which had the Contagious Diseases Act under consideration.* The proposal, viewed in relation to its professed aim, is of course open in the very utmost degree to the objections which I have just stated generally against permissive legislation; indeed, I can scarcely conceive that, if enacted, it would in any single case be of good effect; and there is a different point of view in which I would venture to submit that its admissibility (as well as that of any permissive legislation) requires to be most cautiously considered. For it seems to me that the proposed legislation, powerless though it would be for any sanitary result, would in principle be the thin end of a wedge; that the question of its acceptance or rejection is, as precedent, of fundamental importance; that, between permissive general legislation to-day and compulsory general legislation to-morrow, there would stand but the question of expense. In courses called tentative it is so easy to drift into positions which become pledges, that I venture to press this consideration. Whether the venereal diseases of the civil population are henceforth to be deemed matter of public concern, whether the civil fornicant may reasonably look to constituted authorities to protect him in his commerce with prostitutes, is the principle which I conceive to be at stake. And I would repeat my opinion that, if that principle is affirmed, the responsibilities implied in it cannot be adequately met without stringent compulsory general legislation.

as to local Acts.

Whether particular municipalities wishing to exercise within their respective jurisdictions special powers in relation to venereal diseases might properly be let acquire such powers by purely local Acts of Parliament, is, I think, a somewhat different question; and possibly such special Acts (provided they contained proper obligatory provisions) might, in certain cases, be conceded without any sacrifice of the real principles which are at stake. Every such case would then have to be judged on its own merits. But as regards any general legislation, whether compulsory or permissive, in regard to the venereal diseases of the civil community, my conclusion is very decided that at present I cannot recommend any such legislation.

Supplementary remarks:

Finally, there are some incidental considerations to which I beg leave briefly to advert.

Prostitution, and the ways of reducing it:

Among arguments put forward to recommend a general superintendence of prostitution, there is one which seems to have gained for the proposal a considerable quantity of non-medical, particularly clerical, support. The report of the Association, namely, alleges "that a collateral but not unimportant result

* I describe the financial basis of this proposal as "almost entirely" voluntary contribution. The proposal, as I understand it, is that Government should be authorized to confer the requisite police powers for sanitary superintendence of prostitution on any local authority shown to have at command (as by voluntary contribution) the proper hospital accommodation for such purposes. And the proposal seems to assume that, if lock hospitals were established by voluntary contribution, the local authority could provide (presumably from proceeds of rates) for the cost of the medical inspections and police arrangements.

which inevitably follows the establishment of preventive measures is the improvement in the moral and social condition of the women;" and a memorial which was last year addressed to the then Lord President of the Council, by the President of the Royal College of Physicians and others, supported the view "that, of the unfortunate women who are subjected to these restrictive and sanitary measures, a comparatively large proportion have been reclaimed." I believe it to be unquestionable that such women as have hitherto come under medical inspection have generally been influenced by it to become cleanlier in their persons, and that the brothels inspected by police are less apt than they were to be scenes of riotous disorder; changes, on which no doubt the users of those persons and places may congratulate themselves; but which cannot without extreme abuse of terms be described as of any moral significance. On the other hand, the last clause of the statement cannot fail to seem morally important to anyone who accepts it without reserve. I fear, however, that such hopes as it at first sight would seem to justify, as to possible moral results of a government superintendence of prostitution, would on any large scale show themselves essentially delusive; not, perhaps, as regards individual reclamations to be effected, even from brothels, by pure and kindly human contact, but as regards the statistics of prostitution, broadly and practically considered. For I apprehend that the concubinage-market, like other markets, tends to be fed according to demand; and that, if prostitution is really to be diminished, the principles of those who would diminish it must be preventive. Of the many roots of the evil some are practically immutable, but others will undoubtedly vary with the general moral sentiments of the time. Always, of course, there are certain large quantities of mere brute passion, forcing at any price to have their way; and always, in our present social state, there are large unintelligent masses of human life with little sense of right and wrong, and much of abject poverty ready to sell itself for food, and even more of uneducated frivolous temperament. But if these be regarded as in my present sense "fixed" elements (though indeed all of them are happily susceptible of reduction) a comparatively very variable force is represented in the influence of public opinion. That parents of the educated classes regard with immeasurably different degrees of interest the chastity of their daughters, on the one hand, and the continence of their sons, or future sons-in-laws, on the other, is a fact which probably has its basis in a doctrine of supposed general consequences; but knowledge which is supplied in studying the venereal diseases of the civil population—a knowledge of the mischief and misery which a young man's transient incontinence may be preparing for his whole future domestic life, certainly gives room for consideration whether these ingredients of the one case ought not to be more popularly understood. The only state of things which can be regarded as essentially antagonistic to prostitution is the system of early marriages: which, in this respect, commends itself equally on moral and physical grounds; for, in proportion as it is accepted, the promiscuous intercourse of

the sexes ceases to excuse itself by circumstances, and the chances of venereal infection fall to the lowest level they can attain.

Hospitals for diseased prostitutes.

Also in conclusion I would beg leave (though perhaps superfluously) to protect parts of my above argument from misapprehension. In the proposals which I have had to criticise, hospitals for diseased prostitutes have not come under discussion as charitable institutions, but solely as elements in a machinery proposed to be constituted by law for giving an artificial security to promiscuous fornication. In the latter sense I may have seemed indifferent to their existence; but in the other sense, if this occasion permitted, I would willingly plead in their favour. For some thirty-five years of hospital-surgery in London have given me the amplest opportunities of knowing what physical miseries (as well as what worse mental states) attach to the career of prostitutes; and in this point of view I cordially agree with those persons who deplore the extreme insufficiency of hospital accommodation provided among us for prostitutes venereally diseased. The defect may not be for legal remedy, but not the less it is real, and I sincerely hope it may be dealt with by agencies appropriate to its nature. Such are not for me here to discuss. But considering how large a proportion of society has responsibilities of causation or connivance in that sphere of suffering and shame, and considering again what case for compassion even those who are purest from such responsibilities may recognize in states of human life so estranged and so bitterly punished, I should suppose that dictates of justice on the one side, and impulses of charity on the other, would respond, and not parsimoniously, to any well-considered appeal in the matter.

VI.—Question of consolidating and bringing into System the Laws and Administrative Agencies which concern the Public Health.

I have stated that during the past year much consideration has had to be given in this department to *questions of improvement of system* in the laws and legally constituted machinery which purport to provide for the public health of the country: and it may be convenient that in this place I briefly state my experience of the present system, and my opinion of the reforms which are wanted in it.

Spirit of the present sanitary laws.

It would, I think, be difficult to over-estimate, in one most important point of view, the progress which during the last few years has been made in sanitary legislation. The principles now affirmed in our statute-book are such as, if carried into full effect, would soon reduce to quite insignificant amount our present very large proportions of preventable disease. It is the almost completely expressed intention of our law that all such states of property and all such modes of personal action or inaction as may be of danger to the public health should be brought within scope of summary procedure and prevention. Large powers have been given to local authorities, and obligation expressly imposed on

them, as regards their respective districts, to suppress all kinds of nuisance, and to provide all such works and establishments as the public health primarily requires; while auxiliary powers have been given, for more or less optional exercise, in matters deemed of less than primary importance to health; as for baths and wash-houses, common lodging-houses, labourers' lodging-houses, recreation grounds, disinfection-places, hospitals, dead-houses, burial-grounds, &c. And in the interests of health the State has not only, as above, limited the freedom of persons and property in certain common respects: it has also intervened in many special relations. It has interfered between parent and child, not only in imposing limitation on industrial uses of children, but also to the extent of requiring that children shall not be left unvaccinated. It has interfered between employer and employed, to the extent of insisting, in the interests of the latter, that certain sanitary claims shall be fulfilled in all places of industrial occupation. It has interfered between vendor and purchaser; has put restrictions on the sale and purchase of poisons, has prohibited in certain cases certain commercial supplies of water, and has made it a public offence to sell adulterated food or drink or medicine, or to offer for sale any meat unfit for human food. Its care for the treatment of disease has not been unconditionally limited to treating at the public expense such sickness as may accompany destitution: it has provided that in any sort of epidemic emergency organized medical assistance, not peculiarly for paupers, may be required of local authorities; and in the same spirit it requires that vaccination at the public cost shall be given gratuitously to every claimant. The above survey might easily be extended by referring to statutes which are only of partial or indirect or subordinate interest to human health; but, such as it is, it shows beyond question that the Legislature regards the health of the people as an interest not less national than personal, and has intended to guard it with all practicable securities against trespasses, casualties, neglects and frauds.

The intentions frustrated in detail:

If, however, we turn from contemplating the intentions of the Legislature to consider the degree in which they are realized, the contrast is curiously great. Not only have permissive enactments remained for the most part unapplied in places where their application has been desirable: not only have various optional constructions and organizations which would have conduced to physical well-being, and which such enactments were designed to facilitate, remained in an immense majority of cases unbegun; but even nuisances which the law imperatively declares intolerable have, on an enormous scale, been suffered to continue; while diseases which mainly represent the inoperativeness of nuisance-law have still been occasioning, I believe, fully a fourth part of the entire mortality of the country. And when inquiry is made into the meaning of this strange unprogressiveness in reforms intended and in great part commanded by the Legislature, the explanation is not far to seek. Its essence is in the form, or perhaps I may rather say the formlessness, of the law. No doubt there are here and there other faults. But the essential fault is that laws which

ought to be in the utmost possible degree simple, coherent and intelligible, are often, in nearly the utmost possible degree, complex, disjointed and obscure. Authorities and persons wishing to give them effect may often find almost insuperable difficulties in their way; and authorities and persons with contrary disposition can scarcely fail to find excuse or impunity for any amount of malfeasance or evasion.

and how ?

The many mere ambiguities and minor oversights of the law need not here be insisted on; for the broad jurisdictional state of the case is in itself enough to account for miscarriage.

Local authorities: in common health-areas:

Except where special health-areas have been constituted under local Acts of Parliament, or under the Public Health and Local Government Acts, the local administration of the nuisance-law in regard of its most rudimentary objects is not vested in one single authority for each place, but is distributed, with very disputable demarcation-line, between two. And as regards the distribution of voluntary improvement-powers in such places, there may be one authority for common lodging-houses, another for labouring classes lodging-houses, another for baths and wash-houses, another for burials; and all these authorities separate from the two authorities which have to do with nuisances and drainage and water supply, and from the authority which has to do with highways.

in special health-areas.

It is true that, where special health-areas exist, matters are on a better footing as regards the consolidation of nuisance-powers and improvement-powers in the hands of the town-council, improvement commission or local board; but just in these cases a new kind of evil crops up: for, except by accidental coincidence, these special health-areas do not form units of area in the population-statistics of the country; and it consequently very often occurs that these districts (which peculiarly might be expected to be able to show an intelligible balance-sheet in regard of their expenditure of life) have really no separate statistics even of their births and deaths. Also these special health-areas have not, except sometimes accidentally, any relation whatever to the areas of poor-law relief; and a medical officer of health acting for the health-authority of the town has no official relations with the medical attendants of the sick poor.

Central authorities.

Then (secondly) as regards central jurisdiction in nuisance-law and kindred matters, the conditions are equally unmethodical. Proceedings which stand to one another in the relation of first and second stages of legal intention are the responsibilities of two different chief ministries: on the one hand, inspectional and admonitory proceedings, such as my Lords of the Council direct through this department, in relation to local excesses of disease, and their causes; and, on the other hand, coercive proceedings, which the Secretary of State is empowered to take, in regard of defaulting nuisance-authorities: proceedings of the latter sort being hardly conceivable except on foundation of proceedings of the former sort. This of course is no insuperable difficulty; for the departments concerned can easily adjust their boundary line; but unfortunately in our sanitary code there are other and less superable wants of method. The essential responsibility

for superintending the state of the public health is integrally vested in the Lords of the Council; but fragments of co-ordinate responsibility in the same subject-matter are also vested (for purposes more or less special) in the Home Secretary and in the Board of Trade; and thus one given subject-matter may be under consideration in two or even three Government offices, and each of these offices be required to communicate with the public concerning it.

Relations of Government to localities.

Thirdly, as regards the relations between central and local authorities, a very unfortunate state of things is represented in the absence of certain lines of communication. Government is supposed to supervise the state of the public health: but Government may remain for long periods of time uninformed even of extremely important local outbreaks of disease. This is constantly happening with regard to typhoid fever and other nuisance-diseases of the country; and a very suggestive illustration of the fact is, that, when diphtheria was first beginning to re-appear on a large scale in this country after an interval during which the medical profession had lost all memory of it, very fatal local epidemics of what seemed a new disease were going on for two years (1855–7) in various parts of England, with the central authority of the country absolutely unapprised of the fact. In this connexion too it deserves notice, both as a matter affecting the relations of central to local jurisdictions, and indeed also as affecting the efficiency of the local authorities themselves, that, with regard to some essential elements for proper judgment as to the health of districts, the law does not even provide for the knowledge being systematically in existence. It provides, no doubt, that causes of death shall be registered; but no provision is made that the causes shall have been medically certified; and to my knowledge it has happened in regard of whole counties that, through the general absence of proper medical certificates, with the accompanying misuse of medical language by lay certifiers of death, very deceptive impressions have been given as to the local prevalence of particular diseases. A similar fault of system is shewn in the fact that no available medical returns are made of sickness locally treated at the public expense. Nor, I need hardly add, are any such returns made as to the sickness treated by our innumerable quasi-public medical charities.

Causes of the chaotic state of law.

It would be useless, though not difficult, to explain in detail how the above-described unsatisfactory state of law has come to exist. Broadly it represents two sets of causes. On the one hand, the legislature in all these matters has evidently meant to proceed very cautiously and tentatively; and the many successive stages of attempt, while co-apparent in the statute-book, show of course a good deal of awkward piecing and overlapping, and probably more or less of accidental inconsistency, as well as a certain quantity of ground not yet covered by legislation. On the other hand, the impulses to legislation have come from many different quarters, including two or three departments of Government; and simplifications and coherency of result, such as might have been attained if all had originated from or converged to a single chief ministry for

Remedial legislation.

the subject-matter, are merits which, from the nature of the case, could not be expected.

I venture to submit for consideration whether now the time has not come when a better state of things than I have described can be, and ought to be, constructed. For in regard of some very considerable parts of sanitary legislation, including the machinery by which effect is to be given to the law, the purposes of tentative proceeding have now, I apprehend, been amply fulfilled; and there exists undoubtedly a very urgent public need, that the intentions of the legislature in the present most important subject-matter should as soon as possible, and as completely as possible, be embodied, intelligibly and harmoniously, in clear consolidating law. In contribution to this result I avail myself here of the opportunity to submit some suggestions as to what, in my opinion, are the chief objects for endeavour, and what the broad outlines of such system as might easily be attained, for sanitary government in England.

Nuisance law:

A. That the nuisance-law of England (using the word *nuisance* in its largest sanitary sense) should be put on a satisfactory footing, as regards authorities and areas of jurisdiction, seems to me the first object to be aimed at; and the opportunity would probably be found convenient for making also some extensions which are wanted as regards the scope or object-matter of the present law. Of the chief objects which I think desirable under these heads, the following is a more particular statement:—

to be consolidated with local improvement law:

a. I think it essential that the separation which recent Sewage Utilization Acts have established between nuisance-authorities and sewer-authorities should cease; that every nuisance-authority should also be sewer-authority in the fullest sense of the word; that in the hands of this consolidated health-authority should also be vested all such powers as now attach to several different authorities and corporations for purposes of local improvements and inspections in the physical interests of the people, in regard of burial grounds, baths and wash-houses, labourers' dwellings, common lodging-houses, recreation-grounds, paving, lighting, &c.

jurisdiction in special health-areas:

b. That cities and towns with developed municipal government should constitute special health-areas, having as health-authorities their respective town-councils, improvement commissioners, or other local boards, is a present state of law which of course would be continued; and the utmost facilities ought also, in my opinion, to be given (akin to those which the Local Government Act now gives) for the creation of new special health-areas, and for the variation of existing special boundaries, where required by

in ports:

local conditions. It seems probable that ports and harbours, with all shipping contained in them, must at least to some extent be regarded as special health-areas, having the harbour-authority for health-authority; and, if so, that, for cases where it would be convenient, the harbour-authority might be empowered to appoint some permanent officer to act as health-authority in its stead.

in common health-areas.

c. As regards places not constituted special health-areas, choice has to be made between several courses; and the one which on the whole

I think has great balance of advantages in its favour is that of consistently adhering to the intentions of Mr. Lowe's Nuisance Act of 1860, by letting the common health-areas be the union-areas of poor-law jurisdiction, and identifying the common health-authorities with the common destitution-authorities of the country. The poor-law division of the country is a long-accomplished and locally well-known division, which furnishes limits to many local relations, and, not least, fixes the Registrar-General's "districts" for statistics of population and births and deaths: every union has its administrative board, presumably of the best sort which the area can be expected to give for any purpose of local government, and carefully constituted on the double basis of rate-paying suffrage and ex-officio qualification, and moreover so constituted that each parish of the union is represented in it: and this authority has its fixed meeting-place and meeting-times: it has its permanent clerk, qualified in law: and it has, always acting in detail over the whole union-area, as visitors of the poor and their dwellings, a staff of other permanent officers, medical and non-medical. No approach to such organization as this exists for any other purpose in the rural districts of the country; and it would seem to me a simpler and safer course to bring the common health-service of the country ~~within scope of~~ that existing organization than to attempt a differently planned organization for objects exclusively of health. Among plans which may be conceived as alternatives to the above, it might be proposed to revert to some such parochial system as that of Sir Benjamin Hall's Nuisance Act of 1855, or to develop the parochial system of ~~Sir George Grey's~~ Sewage Utilization Act of 1865; but any parochial system, if not to be utterly abortive, would have to provide for the constitution of boards and offices for each parish with an elaborateness which would often seem most disproportionate; and the result when obtained would be a jurisdictional system conterminous with little except the system of church-rates. Other sorts of plan might aim at establishing a system of county-boards, with some sub-scheme, perhaps of descending scale, for smaller (say, at last parochial) sub-jurisdictions; but here again the law would fail, unless it provided for the boards and officers of the sub-jurisdictions; and all this apparatus, because of its novelty, would have to be planned so minutely, as compared with the actual work to be done in each rural sub-jurisdiction, that it could scarcely not seem excessive and pedantic. And in any of these alternative plans there would be difficulty in avoiding what, if it occurred, would be matter for extreme regret, an entire dissociation of the local health-machinery from that universal system of medical attendance which exists for purposes of the poor-law.

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d. If, however, the common health-areas of the country are to be the areas of poor-law unions, and the local authorities acting for destitution are to be the local authorities acting for health, there are three conditions which I think ought to be observed. First, regard being had to the great extent of most rural unions, and to various other considerations, it is peculiarly necessary that

Relation of health-authority to authority for destitution: in common health-areas:

the authority should be well empowered to act through committees, both for divisions of district and for divisions of subject-matter; and probably it would be convenient that such committees should be able to include persons not members of the original board. Secondly, regard being had to the frequency with which neighbouring districts have joint interest in questions, as particularly of drainage and the like, each authority ought to have facilities, and in certain cases obligation, to combine for particular purposes, by committee or in entirety, with other neighbouring authorities. Thirdly, I think it scarcely less than essential that any law which connects for local administration the two services of health and poor-law relief should do so in a different form to that of the law now in force. At present in all common health-areas of the country the board of guardians of the poor is the nuisance-authority; but it is so *ex officio;* and this peculiar form of law not only gives to the health-interests of the place an undue appearance of being of secondary importance, but also sometimes leads the guardians to think themselves surcharged with duties foreign to their real business. It seems to me highly desirable that, if the two administrations are to be associated, the board should be appointed, *ab initio*, expressly for the compound purpose, and should be invested by law with a new title denoting its double functions as authority for health and destitution.

in special health-areas.

e. Within almost all special health-areas of the country the health-authority is, and I must assume will for the present continue to be, distinct from the destitution-authority of the place. I accept this as fact, but I doubt if it is to be deemed an advantage. I suspect it would generally be of benefit to municipal administration if one single board, with sufficient power of acting by committee, were elected for all purposes of local government, including the relief of destitution.

Local medical services under health-law.

f. As regards certain medical services to be locally rendered in aid of health-authorities as such, I think, first, that every health-authority should be empowered to appoint a special health-officer; secondly, that wherever there is a special health-area the appointment of a special health-officer should be imperative; thirdly, that for areas where the destitution-authority is also the health-authority, the rule ought to be that, if no special health-officer is appointed, each medical officer acting under the destitution-authority should be deemed health-officer within the limits of his own medical relief district.* I think it indispensable that everywhere throughout the country there should be an officer to whom the local authorities and the public may look for those definite occasional acts of inspection and certification which an amended health-law would certainly require from time to time to be executed, and to some of which I shall hereafter refer; but it is obvious that

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* For brevity, I use the word "health-officer" without qualification: but I may observe that the functions for which I am here proposing to provide universally are only such few rudimentary functions as attach to a minor health-officer, and that the question of superintendent health-officers, acting for counties or other large areas, is one on which I do not at present enter.

in many of the common health-areas of the country occasions for this sort of action would be so few that probably the services might best be paid by fees. In all important special health-areas, on the other hand, the services would be more or less continuous; but it could only be in some very few cases that the duties of the health-officer in a single health-area would represent entire occupation of his time; and therefore, for other cases, it seems to me greatly to be desired, with a view to procuring proper cultivation of the required medical accomplishments, that the special health-officer of one town should be free to be special health-officer to another; and that the two parties concerned should so avail themselves of this freedom that the special health-officer might be able to dispense with ordinary professional practice, and that the towns employing him might be able to secure a very high quality of special service.

Extension of legal definition of "nuisance."

g. The system of summary procedure which is the essence of our modern nuisance-law (subject, of course, in certain cases to appeal to a superior court) ought in my opinion to be extended as far as practicable to all influences by which the public health is endangered, and the word "nuisance" for the purposes of the law to be applied to every such influence. Especially, it seems to me, that all such pollutions and obstructions of streams as may be of ill consequence to the public health ought to fall within the law of nuisance.

Regulation against recurrent nuisances.

h. With regard to all such sorts of nuisance as are likely to be recurrent or habitual, the central authority, and with its consent local authorities, ought, I think, to be able to make regulations ~~and to affix penalty to breaches of them.~~

Proceedings.

~~*i.* All proceedings under the~~ nuisance-law might, I believe, with advantage be open indifferently to any person aggrieved, and to the local authority, and to the central authority.

Other conterminous medical responsibilities:

B. Two very important medical responsibilities, not arising under the nuisance-law, nor under the poor-law, but created by special Acts of Parliament, have at present to be discharged, the one entirely, and the other almost entirely, by the respective destitution-authorities of unions and parishes, viz., first, public vaccination, and, secondly, medical relief in epidemic emergencies.

public vaccination:

a. The authority for public vaccination is now universally the destitution-authority, which in all common health-areas is identical with the nuisance-authority, but in all special health-areas is separate from it. Under the system I am suggesting, public vaccination in the common health-areas would remain substantially unchanged; it would be one of the health-functions of the double-functioned local authority; but as regards special health-areas, it would certainly admit of question whether public vaccination ought not rather to be a function of the consolidated health-authority than a function of the authority for destitution; and I am myself disposed to think that in those areas the transfer would generally be desirable.

action under Diseases Prevention Act.

b. Exceptional medical relief in epidemic emergencies (as requirable under the Diseases Prevention Act) is so essentially a

mere temporary increase of the ordinary medical relief of the poor, that I think it ought always to be a function of the authority which administers the ordinary relief. Thus, under present poor-law, the function would everywhere attach to the destitution-authority of the place. With regard to special health-areas, where almost universally the destitution-authority and health-authority are mutually independent bodies, the law ought to take security for all necessary co-operation of the two sets of officers; and this not only when the Diseases Prevention Act is in operation, but equally as to all ordinary relations between the preventive and curative jurisdictions.

Local medical functions attributable over larger areas.

C. Beyond the purview of such laws as I have yet spoken of, very important sanitary objects yet remain to be provided for by some sort of local administration. Such are the protection of the public against sale of adulterated and damaged food, and against malpractices of water-companies, and against offences under the Pharmacy Act; proceedings as to the diseases, especially the contagious diseases, of domestic animals; provision of skilled assistance to local magistrates when crimes against life are imputed, &c. As regards all these matters, some distinctive principles are involved, making it in my opinion for various reasons inexpedient that here the local authorities should be such as have hitherto been under consideration. One immensely important group of functions under the present head is to protect the public health against various kinds of commercial wrong; and if powers for this purpose are to be strongly and impartially exercised, it would seem desirable, first, that the areas of jurisdiction should be as large as conveniently may be, and then that the empowered authorities should rather be of magisterial type than consist of boards constituted by annual popular election. Probably the magistracy of boroughs and counties, as represented in courts of quarter-session, would be the best local authority in the matter; and it might, I submit, be required of each of these courts to appoint a public analyst, with definite duties under the adulteration laws, and with reference to public supplies of water, and various like matters. It seems to me that, for all health-matters not in the hands of nuisance-authorities or destitution-authorities, an uniform constitution of authority on this magisterial basis might very conveniently be provided; bringing more or less completely into one system the local supervision of branches of trade which concern life, and the local supervision of cattle diseases, and the local supervision of lunatic asylums, and local arrangements for providing skilled evidence in aid of coroners' inquests.

On the present occasion my subject-matter consists so especially of questions of method and organization, that I must here pass without mention many points where the law seems to me in other respects to require amendment; but I may observe in passing, that many of the most important objects which I propose should be matters of quarter-sessions authority are hitherto very imperfectly provided for by law.

Central authority in regard of regulations and sanctions.

D. For certain cases where public health is in question, the central authority is authorized by law to issue orders and regulations which, when issued, have the force of law in relation to the local authorities addressed. And in certain other cases the right of local authorities to take particular courses of action is by law made contingent on the central authority's giving approval to such courses. What ought to be the precise extent of the discretional control to be thus exercised by central authority in local affairs is not a question which needs here be discussed; but the number of cases which statute-law cannot touch in exact terms is so great, that manifestly, if such law is to work with promptitude and ease, it must, to a greater or less extent, be supplemented by that elastic margin of what may be called law in reserve.

Ordinary relations between central and local authorities.

E. The ordinary administrative relations which the law supposes to exist between local authorities and central authority in relation to the public health are in substance two:

first, that the central authority watches the fluctuations of health in all the health-areas of the country respectively;

and, secondly, that, discovering from indications thus supplied the cases where health-law is not properly administered, it takes steps, which in the last resort may be coercive of local authorities, to procure proper obedience to the law.

The extent to which the law imposes definite obligations on local authorities assigns of course a limit to the central authority as regards the class of cases where its coercive interference is possible; but far beyond that limit, as well as also within it, innumerable cases present themselves, where mere information and advice from the central authority may be influences of the utmost value in determining local authorities to right measures for the public health. It is manifest that functions of this sort cannot be exercised by any central authority except in proportion as it is cognizant of local variations in the public health: proper provisions for making all such variations known to the central authority are therefore elementary necessities in that mixed system of central and local government which the law has intended to operate for sanitary purposes in England: and greatly to improve the provisions which now exist in this country for recording and reporting the deaths and sickness of the community, is, in my opinion, an object of quite fundamental importance among such improvements of method as I am considering. The chief points where I think amendment wanted for purposes of general administration are as follows:

Knowledge of deaths to be made available:

a. With regard to the knowledge which ought to be had concerning the deaths of the population, I have three suggestions to make.

medical certificates:

First, in my opinion, the law ought as far as practicable to require in every case of death that the cause of the death be medically certified. Exception, not in substance but in form, might have to be made for cases where coroners' inquests are held; *i.e.*, the verdict of any such inquest must of course be understood to include the substance of any required medical certificate. And

possibly, for very exceptional circumstances, it might be desirable to provide that, in them, any magistrate's order should exonerate from the necessity of the certificate. But, subject only to such qualifications as these, it seems to me that in all cases of death a medical certificate of the cause of death ought to be required; a certificate to be obtained, where practicable, from the medical practitioner who attended the fatal illness; or, where there has been no medical attendant, or none from whom a certificate can be obtained, from the public health-officer of the district.

local distribution;

Secondly, I think it essential that the division of the country for purposes of census and registration of births and deaths should, as far as practicable, treat as separate districts or sub-districts all areas which are separately identified for purposes of health-administration. New special health-areas are constantly in course of formation under the Local Government Act, and perhaps otherwise; and I would suggest that, as soon as possible after the formation of any such special health-district, it should be created a district or sub-district for purposes of registration and census.

statistical returns.

Thirdly, I refer with admiration to the detailed numerical statement which the Registrar General issues every Tuesday on the subject of the deaths of the metropolis during the last preceding week: a statement which relates to three millions of population occupying 137 separate sub-districts, and which not only gives the gross number of deaths for each sub-district respectively, but distinguishes also for each sub-district the more important causes of death; so that persons interested in the health-administration of London are able at a glance to see, with considerable minuteness, in what parts of London each of the principal zymotic diseases has been fatal during the previous week, and what number of deaths in each sub-district each such disease has produced. If what is thus done every week for about a seventh part of the population of England could be done for the whole population, not every week, but every quarter, this quarterly publication would represent one of the most important aids which could be rendered to the health-administration of the country. The present quarterly returns of the Registrar General state what gross number of deaths has occurred in each registration-district of the country; and a few of the sub-district registrars comply with a request which the Registrar General has during some years past made to all of them for "notes" on the prevalence of particular diseases in their sub-districts. But not even an approximative opinion as to the distribution of disease in the country can be formed from these imperfect and uncertain materials; and it is not till nearly two years later that the detailed results of the registration of deaths can be gathered from the annual reports of the Registrar General. A system of quarterly death-reports for the entire country, in general conformity with the weekly death-reports which are given for London, is therefore among the amendments for which I hope.

Knowledge of sickness to be made available.

b. With regard to the knowledge which ought to be had concerning the sickness of the population, I think that, greatly for immediate purposes of medical science and health-administration, and in an even higher degree for common purposes of public

economy, certain broad information ought periodically to be given as to the quantities and kinds of sickness treated by the several destitution-authorities and by the several medical charities of the country. As regards the former, it would seem desirable that at fixed intervals (say quarterly) each destitution-authority should state in a fixed tabular form, for each of its medical relief districts, what numbers of cases of disease generally, and of a few of the more important epidemic diseases individually, had been remaining under treatment at the commencement of the period; and what numbers had been remaining at the end; and what numbers of new cases had come under treatment during the period; and what number of deaths had occurred among new cases and old cases respectively. And as regards medical charities, I venture to suggest that, in the rightly understood interests of their subscribers, no less than for other ends to which I have referred, a system of uniform registration, and an uniform contribution of annual returns, ought to be claimable from them by the central authority, in reference to the sexes, ages, numbers, and kinds of cases treated by them respectively, and to the duration and results of treatment.

Central authority.

F. That any central offices which have to do with sanitary affairs ought, like the local authorities and jurisdictions, to be methodically related to each other and to the public, on some simple consistent plan, according to their respective subject-matters, is of course indisputable: but this section of the argument does not here require at my hands more than a few explanatory remarks. If the present central offices which are more or less concerned in the question be regarded according to their main intentions, and therefore without reference to such minor flaws and uncertainties of jurisdiction as any consolidated law would at once rectify, the following may be taken as their scheme.

Lords of the Council.

a. The functions which my Lords of the Privy Council exercise through their Medical Officer, and for which the Medical Department of the Council Office is constituted under the Public Health Act, 1858, are the essentially sanitary functions of Government: such as the following:

to take practical cognizance of all important faults and fluctuations of the public health, general or local; looking at each such fault or fluctuation as a question of cause and effect, and examining for the common interests whether in each suffering or endangered place everything is done which ought to be done in prevention of the beginnings or spreadings of disease; and thus and from other points of view to act in supervision of all local health-authorities as such, and to give them such advice or to adopt such other measures as the circumstances in each case may shew necessary;

to provide an office of reference and appeal for local authorities and for the people generally on all considerable sanitary influences operating in the country, and on all other public questions of causation and prevention of disease, so far as the knowledge of the time enables such questions to be answered, an office in which scientific knowledge of this sort shall be

systematically gathered and reported for public use, and in which, so far as practicable, such knowledge shall be increased from year to year by special scientific investigations;

to issue, and afterwards to superintend in operation, such orders, regulations and sanctions, as the Government with medical advice sees fit, in relation to various special matters which the Legislature has made subject to this control: as local provision against epidemics, performance of public vaccination, questions as to practice of pharmacy and sale of poisons, questions as to the medical profession, &c.

Home Office.

b. There are two offices which, by a part of their subject-matter, have close, though not extensive, relation to the Medical Department of the Council Office; two offices, namely, which both are under direction of Her Majesty's Home Secretary of State. On the one hand there is the great arithmetical office, over which the Registrar-General presides: the office to which the public looks for all numerical information obtained by periodical census and from local registers, as to the numbers, ages, sexes, birth-places, industries, and family-combinations of the people, and as to the marriages, births and deaths, which take place amongst them: and I need hardly observe that one part of this statistical information constitutes an indispensable basis for some proceedings in the Medical Department. On the other hand, there is the office through which the Secretary of State, under authority of the Local Government Act, controls the exercise of rating and borrowing powers for purposes of local improvement under the Act, and, incidentally to this control, has before him for skilled criticism the various proposals of local authorities for drainage, sewage-utilization, &c. And as this office (essentially including a staff of engineers) has been found the most convenient machinery through which the Secretary of State can advise, and in case of need enforce, in regard of localities, certain constructional improvements which may be needful for the health of the inhabitants, so, in the particular cases where necessities of this sort are in question, the action of Government may be considered as consisting of two stages: the first conducted in this department of the Council Office, and the second conducted in the local improvement office of the Home Secretary. This department then, which is essentially medical, has an important point of contact with each of those two non-medical offices: but the three subject-matters, in their main extent, are necessarily separate for administration. Whether the three offices ought still to remain as now divided under two chief ministers, or might more conveniently be all made subject to one, and, if so, to which one, are questions which of course involve many other considerations than those on which it is my province to enter. I am however permitted to state that these questions, with others relating to the distribution of central sanitary work, are at present being considered by the Ministers whose departments they specially concern.

JOHN SIMON.

APPENDIX.

No. 1.—Statistics of the National Vaccine Establishment, and Educational Vaccinating Stations.

Appendix.

No. 1. Statistics of the National Vaccine Establishment, and Educational Vaccinating Stations.

1. Staff at end of 1868.

N.B.—The Stations named in *italics* are Educational Vaccinating Stations, authorized by the Lords of the Privy Council, for the purposes of their Lordships' Order of December 1, 1859.

—	Names.	Vaccinating Stations.	Days and Hours of Attendance.
Vaccinators supplying lymph for the public service and salaried from the Parliamentary Grant.	1. Mr. John N. Tomkins, *Inspector.*	Fitzroy Street.	Daily, 10—11.
	2. Mr. J. F. Marson -	*Surrey Chapel.*	Tuesd., Thursd.; 1—2.
	3. Mr. G. L. Cooper -	Battle Bridge.	Tuesday; 12—1.
	4. Dr. R. Sharpe -	Bermondsey.	Tuesday; 10—11
	5. Mr. R. Wade -	Dean Street, Soho.	Monday; 9—11.
	6. Mr. A. B. Macann -	King Street, Portman Square.	Monday; 10—11.
	7. Mr. Wm. J. Lewis -	Spital Square.	Monday; 10—11.
	8. Mr. Wm. J. Lewis -	*Wellclose Square.*	Tuesday; 9—11.
	9. Mr. W. E. G. Pearse	*Tottenham Court Chapel.*	Mond., Wednesd.; 1–2.
Parochial and other Vaccinators not salaried from the Parliamentary Grant, but furnishing Lymph at a fixed rate of payment.	1. Mr. Ellis S. Guest -	*Manchester.*	Monday; 2—4.
	2. Dr. G. F. De la Cour	*Birmingham.*	Monday; 10—12.
	3. Dr. H.A.P. Robertson	*Bristol.*	Tuesday; 11—12.
	4. Mr. A. B. Steele - Mr. J. H. Wilson - Mr. John Fenton -	*Liverpool.*	Monday; 9. Friday; 2.
	5. Dr. E. L. Webb -	*Pimlico.*	Monday; 10—12.
	6. Mr. G. C. Gilchrist -	*Newcastle-on-Tyne.*	Tuesday; 2—3.
	7. Mr. W. E. G. Pearse	*Westminster.*	Monday; 9—11.
	8. Mr. J. G. Gerrans -	*Marylebone.*	Monday; 10—11.
	9. Mr. Frederick Holmes	*Leeds.*	Tuesday; $3\frac{1}{4}$.
	10. Dr. Edward Lynes -	Coventry.	Monday; 12—2.
	11. Mr. Joseph Teale -	Salford.	Thursday; $2\frac{1}{2}$.
	12. Dr. James Dunlop -	*Glasgow.*	Monday; 12—1.
	13. Mr. C. Harriot Roper	*Exeter*	Thursday; 3.
Teachers of Vaccination not supplying lymph.	1. Mr. Robt. W. Dunn	*Strand.*	Monday; 10.
	2. Dr. W. Husband -	*Edinburgh* - -	Wed., Sat.; 12.

APPENDIX.

No. 1.
Statistics of the National Vaccine Establishment, and Educational Vaccinating Stations.

Statistics of the National Vaccine Establishment and Educational Vaccinating Stations—*continued.*

2. SOURCES and AMOUNT of LYMPH SUPPLY in 1868.

N.B.—The Stations named in *italics* are Educational Vaccinating Stations, authorized by the Lords of the Privy Council, for the Purposes of their Lordships' Order of December 1, 1859.

—	Vaccinating Stations.	No. of Vaccinations performed at the Stations respectively. Prim^y	Re-vac^{ns}	No. of charges of Lymph supplied from the Stations respectively.	Remarks.
Vaccinators salaried from the Parliamentary Grant.	1. Fitzroy Street	783	—	4,750	
	2. *Surrey Chapel*	1,252	35	15,750	
	3. Battle Bridge	472	—	5,388	
	4. Bermondsey	748	39	11,078	
	5. Dean Street, Soho	491	13	8,730	
	6. King Street, Portman Square	309	5	5,845	
	7. Spital Square	307	—	9,586	
	8. *Tottenham Court Chapel*	896	20	16,218	
	9. *Wellclose Square*	305	—	9,066	
Total	9 Stations	5,563	112	86,411	
Parochial and other Vaccinators not salaried from the Parliamentary Grant, but furnishing Lymph at a fixed rate of payment.	1. *Manchester*	1,395	—	18,387	
	2. *Birmingham*	1,197	4	5,520	
	3. *Bristol*	517	—	3,812	
	4. *Liverpool*	904	—	17,643	
	5. *Pimlico*	879	8	34,524	
	6. *Newcastle-on-Tyne*	333	1	6,106	
	7. *Westminster*	782	10	16,378	
	8. *Marylebone*	670	38	4,823	
	9. *Leeds*	748	—	18,733	
	10. Coventry	721	—	847	
	11. Salford	1,131	—	7,040	
	12. *Glasgow*	1,079	—	6,601	
	13. *Exeter*	—	—	—	
Total	13 Stations	10,356	61	140,414	
General Total	22 Stations	15,919	173	226,825	

Statistics of the National Vaccine Establishment and Educational Vaccinating Stations—*continued.*

Amount of Lymph Supply.

3. Summary for the Years 1856–1868.

Year.	Total Vaccinations performed at the Stations which supply Lymph.	Re-vaccinations included in preceding Column.	Number of Charges of Lymph supplied.
1856 - -	7,039	?	210,942
1857 - -	6,327	?	213,207
1858 - -	6,445	?	234,150
1859 - -	9,030	?	237,801
1860 - -	13,849	?	228,347
1861 - -	12,009	?	225,000
1862 - -	13,149	?	211,475
1863 - -	20,600	?	239,432
1864 - -	13,727	?	203,250
1865 - -	14,648	515	219,832
1866 - -	14,319	372	207,014
1867 - -	14,911	584	216,637
1868 - -	16,092	173	226,825

APPENDIX.

No. 2.
Further Vaccination Regulations.

No. 2.—FURTHER REGULATIONS by the LORDS of the COUNCIL for securing the efficient performance of PUBLIC VACCINATION, and in respect of the RE-VACCINATION of persons who apply to be re-vaccinated, made and issued February 18th, 1868.

I.—*Places and Times for Vaccination under Contract.*

Public Vaccinator, under ordinary circumstances, to vaccinate only at public Stations;

1. Except where the Privy Council, for reasons brought to its notice, sees fit in regard of any particular district to sanction a system of domiciliary vaccination, every vaccination-district shall have in it at least one public station appointed for the performance of the vaccinations under contract; and where any such station has been provided for a district, no person resident within two miles thereof, and not being an inmate of the workhouse, shall be vaccinated under contract elsewhere than at such station, unless the vaccinator in the particular case be of opinion (which, if so, he is hereby required to note in his register) that, for some special reason, the person whom he purposes to vaccinate cannot properly be vaccinated at the station.

and not oftener than once weekly;

2. Except under special authorization from the Privy Council as aforesaid, or in so far as may be expedient at times when there is immediate danger of small-pox, vaccination under contract shall not be appointed to be performed at any station oftener than once a week.

and, if in a town-district, only at one Station therein.

3. And in any future contract concerning a vaccination district which is partly or wholly within a town, there shall not, except under special authorization as aforesaid, be appointed within the town more than a single station for the performance of the vaccinations of the district.

II.—*Vaccination Districts in Towns.*

Limitation as regards Towns, on the Smallness of Districts for Vaccination.

No part of the metropolis, or of any city, or municipal borough, or town corporate, or other town, shall, in respect of any future contract, form by itself, or with any rural place, a separate district for vaccination, except with the approval of the Privy Council, unless it contain an estimated population of at least 25,000 persons, or else be as much of the metropolis, city, borough, or town, as is for purposes of vaccination under the control of one board of guardians.

III.—*Office of Public Vaccinator.*

Each District to have its own Public Vaccinator.

After the expiration of the month of June next, no two or more persons shall be allowed to act severally as vaccinators under contract in any one and the same part or district of any union or parish.

IV.—*Re-Vaccination.*

Extent to which Re-Vaccination at public expense may be given.

The performance of re-vaccination by the public vaccinator on persons applying to him for that purpose shall be limited in each case by the following conditions: (1) that, so far as the public vaccinator can ascertain, the applicant has attained the age of 15 years, or, if during any immediate danger of small-pox, the age of 12 years, and has not before been successfully re-vaccinated; and (2) that, in the public vaccinator's judgment, the proposed re-vaccination is not for any sufficient medical reason undesirable; and (3) that the public vaccinator can afford vaccine lymph for the purpose without in any degree postponing the claims which are made on him for the performance of primary vaccination in his district.

No. 3.—REPORT by Dr. EDWARD BALLARD, Medical Officer of Health for Islington, on the RESULTS of an ANALYSIS of RECORDS of SICKNESS kept in ISLINGTON during the 12 years 1857 to 1868 inclusive.

THE 26 diagrams represent the fluctuations, week by week, of the more important elements of weather during a period of 12 years, namely from 1857 to 1868, inclusive, together with the variations in the amount of general sickness, and of certain important special forms of sickness, as obtained from records of new cases of disease admitted for treatment in certain institutions where the sick poor are treated in the parish of St. Mary, Islington. The record of weather employed in the construction of the diagrams is that published in the weekly returns of the Registrar General. The parish of Islington is one of the most rapidly increasing parishes in the metropolis. In 1851 the population amounted to 95,329 persons; in 1868 it could not be calculated at less than 200,000. This rapid increase must be taken into account by anyone comparing the diagrams of one year with those of another. The diagrams for the first three years, again, are constructed from the records of the parochial workhouse, and the infant poorhouse, together with those kept by eight medical officers attending sick paupers out of doors, and at the Holloway Dispensary. In 1860 the Islington Dispensary began to keep a record of their new cases of sickness, and from that year forward this institution is included in the diagrams. Beside the variations in the admissions of new cases of sickness generally, I have marked those of respiratory diseases (bronchitis and catarrh, pneumonia and pleurisy), of diarrhœal affections, and of the four common epidemic diseases, small pox, measles, scarlatina, and hooping cough. Diagrams 25 and 26 are of the nature of a *summary* of the twelve years, representing the average weather of each week and the average number of cases of sickness received in each week under treatment. They exhibit the average prevalence of sickness at the different seasons of the year (as deduced from the 12 years' observations), and also that of the several common affections particularized. The total number of cases tabulated for the purpose of these diagrams is as follows:—

Of general sickness	- 272,469 cases.		
Of respiratory diseases -	47,889	,,	= 175·7 per 1,000 of all cases.
Of diarrhœal affections -	16,456	,,	= 60·3 ,, ,,
Of measles - -	5,501	,,	= 20·1 ,, ,,
Of hooping cough -	4,580	,,	= 16·8 ,, ,,
Of scarlatina - -	3,850	,,	= 14·1 ,, ,,
Of small pox - -	1,97	,,	= 7·2 ,, ,,

This table indicates *the order of frequency of occurrence* of these diseases in an average town population, during a period sufficiently prolonged to afford time for the occurrence of several epidemics of each, varying in their degree of severity. It is not the same order as comes out when the deaths occurring in the same period are added up. The deaths among all classes of the resident population in the parish of Islington during the same 12 years were as follows:—

		Per 1,000 of all deaths.
Deaths from all causes - - - -	40,071.	
,, respiratory diseases - -	7,138 =	178·1
,, scarlatina - - - -	2,007 =	50·0
,, diarrhœal affections - -	1,971 =	49·1
,, hooping cough - - -	1,756 =	43·8
,, measles - - - -	1,142 =	28·4
,, small pox - - - -	475 =	11·8

Appendix.

No. 3.
On the Results of an Analysis of Records of Sickness, &c., by Dr. Ballard.

The comparatively small fatality of small pox and measles, and the comparatively very high fatality of hooping cough, and especially of scarlatina, are obvious on a comparison of these two tables. Unfortunately, too, although these latter diseases do not stand high in the list of epidemic maladies for frequency of occurrence, they not only are of high immediate fatality, but by the damage they effect to the lungs and kidneys respectively, they lay the foundation for chronic affections which go ultimately to swell the catalogue of premature deaths.

General Sickness.

The total number of cases of sickness generally, observed during the 12 years, was 272,469. They were thus distributed:—

In 1857	-	12,796 cases.	In 1863	-	26,710 cases.
1858	-	13,836 „	1864	-	23,951 „
1859	-	15,086 „	1865	-	23,447 „
1860	-	21,842 „	1866	-	27,450 „
1861	-	23,326 „	1867	-	27,365 „
1862	-	23,929 „	1868	-	32,731 „

Diagrams 25, 26, exhibit the line of general sickness as it was, on the whole, distributed through the several periods of the year. The diagrams 1 to 24 exhibit the same line for each year of the twelve. It is to be observed that it forms two waves. Commencing from the 22d week in the year (the 1st week in June), when the general sickness was on the whole at its minimum, the first wave rises rapidly to attain its maximum in the 33d week (the 3d week in August); it then descends still more rapidly than it rose during the next four weeks, terminating in the 37th week (the 2d week in September), but with an amount of sickness considerably greater than that with which it commenced. This wave only occupies 15 weeks out of the 52 for its completion. The remaining 37 weeks are occupied with the second and larger wave, which quickly attains its maximum elevation in the 47th week, and thence declines gradually through the winter, and notably through the spring, until it ends in the minimum of the year again in the 22d week.

There is a fallacy to be taken into account in respect of the sickness recorded in December, especially at its close, and in that of the first week of January, which renders the amount of sickness apparently less than in all probability it actually was. I allude to the social and domestic occupations of the people at this season, culminating in the Christmas week, which very evidently deters them from the seeking of medical advice for lesser ailments, such as would at any other time have sent them to the union surgeons or dispensaries. There is observed thus a gradual diminution in the number of new cases week after week as soon as November has closed. The weekly average of new sickness in the last week of November being 470 cases, it fell week by week as follows:—

48th week	-	-	-	463 cases.
49th „	-	-	-	459 „
50th „	-	-	-	459 „
51st „	-	-	-	387 „
52nd „	-	-	-	321 „
1st week Jan.	-	-	-	426 „

Hence, instead of taking the actual returns of sickness for December as indicating the line of sickness at that period of the year, it would be more accurate to supplant them by the mean of the sickness of November and January. Making such a correction we find that, taking the whole sickness of the year as 1,000, the cases are distributed through the several months as follows:—

January	- 84·1 cases	Winter quarter	- 248·5 cases.
February	- 82·6 „		
March	- 81·8 „		
April	- 80·3 „	Spring quarter	- 237·8 „
May	- 78·4 „		
June	- 79·1 „		
July	- 85·4 „	Summer quarter	- 257·7 „
August	- 88·7 „		
September	83·6 „		
October	- 84·2 „	Autumn quarter	- 256·0 „
November	- 86·5 „		
December	- 85·3 „		
	1,000·0 cases.		1,000·0 cases.

Hence the experience of our 12 years in Islington has been on the whole that, of the several quarters of the year, the summer has been the most sickly, the autumn rather less so, but nearly equalling it; that next in order comes the winter quarter, and that the spring quarter has been the least sickly of all.

Of the several months of the year, the order of sickliness has been, August the most sickly, then November, July and December, January and October, September, February, March, April, June, and May, the last being the most healthy month of the year.

Diagram No. 25 shows the relation borne by the line of annual sickness to the average meteorological conditions of the several seasons of the year. The minimum of sickness corresponds with a season at which the mean temperature of the air is just 58·7°, with a mean daily range of about 21 degrees, the mean atmospheric humidity being 76 (saturation 100), with an average rainfall of 0·82 inches, distributed over between two and three days in the week. From this point it is observable that the sickness rises as the warmth of the air rises and the daily range of temperature increases towards the summer months, these conditions being associated with lessened rainfall and greater dryness of the air. But it is further to be noticed, that the summit of the summer wave of sickness is not attained until some four or five weeks after the maximum temperature of the year has been reached, and until a time when the summer heat is in course of subsidence, the daily range lessening and the rainfall and atmospheric moisture becoming greater. The end of the summer wave (the minimum of summer sickness) corresponds with a time when the mean temperature is the same as at the spring minimum of sickness, viz. 58·7°, the daily range of temperature being about 16 degrees, the atmospheric humidity about 78, with a rainfall of 0·50 inch distributed over between two and three days in the week. Comparing the smaller spring minimum with the greater summer minimum of sickness, we may observe that while the mean temperature is about the same at the two periods, the former corresponds with a greater daily range, more rainfall, and rather less atmospheric humidity than the latter. So much for the summer wave.

The greater wave of sickness, which is to occupy the autumn, winter,

APPENDIX.
No. 3.
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and part of the spring, begins to rise as the mean temperature of the year sinks below 58·7°, as the daily range continues to lessen, and as, with these conditions, the atmospheric humidity increases above 78. The maximum sickness is, as has been observed, quickly attained ; the summit of the wave corresponds to a temperature of 41·2°, with a daily range of about 11 degrees, and a relative atmospheric humidity of 88. This wave subsides (unlike the summer wave) very gradually indeed ; it is not peaked like the summer wave, but has a broad summit, very little subsidence occurring until the seventh week of the winter quarter. Still, during these weeks, from the 47th week of the year onwards, a slight subsidence is observed, corresponding to the slight increase of temperature and the slow reduction in the humidity of the atmosphere which takes place in the last few weeks of December and the beginning of the year. The imperfection of the records of sickness (before alluded to) in the last weeks of December and the first week of January interferes with the determination of the influence of the greatest cold in the first week of the year. However, it is clear that the gradual reduction in the general sickness, and most marked subsidence of the large wave, follow almost immediately upon a rise of the mean temperature above 40°, with diminution of the humidity of the air below 84 ; and that they continue as the temperature of the year increases, the daily range becomes greater, and the atmospheric humidity less and less.

In looking at the diagrams one is struck forcibly with the facts, 1°, of the excessive sickliness of the year 1863 ; 2°, of that of the cholera year 1866, from the month of February onwards, not merely of the summer quarter, which would be explicable from the existence of the epidemic ; and, 3°, of the continued extraordinary sickliness of the two years succeeding the cholera epidemic, a sickliness not confined to any one quarter, but extending to all the seasons. There is nothing in common in the ordinary meteorological circumstances of these four years to account for these facts. 1863 and 1868 agreed to a certain extent, in having on the whole a high temperature and in being comparatively dry, but 1866 and 1867 were comparatively cool and wet. 1863 was in all respects a remarkable year as regards sickness ; for not only was the general sickness high, but it was the year of the grand outburst of small-pox, as well as of a serious epidemic of scarlatina, hooping cough being also unusually prevalent. The year 1866 was notorious not only for the cholera outbreak, but also for a severe epidemic of measles and a renewal of the small-pox epidemic. The year 1867 was remarkable also for the great prevalence of small-pox and scarlatina, and 1868 for scarlatina, measles, and hooping cough. The high sickliness of the year 1863 is in great measure explicable by the wide-spread distress arising out of the cotton famine, and 1867 and 1868 were years of greatly depressed trade, and in addition 1868 was a year in which the price of provisions was exceedingly high.

The order of sickliness of the several quarters and months, as deduced from a general view of my experience of the past 12 years, was not, of course, observed every year. During the 12 years—

Summer	stood	highest in the order of sickliness		6	times.
„	„	second	„ „	4	„
„	„	third	„ „	1	„
„	„	fourth	„ „	1	„
Autumn	„	highest	„ „	3	„
„	„	second	„ „	3	„
„	„	third	„ „	4	„
„	„	fourth	„ „	2	„

Winter	stood	highest	in the order of	sickliness	twice.	
”	”	second	”	”	5	times.
”	”	third	”	”	2	”
”	”	fourth	”	”	3	”
Spring	”	highest	”	”	1	”
”	”	second	”	”	1	”
”	”	third	”	”	4	”
”	”	fourth	”	”	6	”

The most uniformly sickly quarter, then, has been the summer, and the most uniformly healthy quarter has been spring. Autumn would probably come out more uniformly high in sickliness, but for the fallacy introduced by its embracing the month of December.

The meteorological conditions which appear to exercise the most decided influence upon the quantity of general sickness are atmospheric temperature and humidity and rainfall. Table I. is constructed with a view to show what these conditions were in the quarters of greater and less sickliness. I have also introduced columns showing the average cost of provisions in each quarter, and the average amount of pauperism. I have excluded the years 1863, 1867, and 1868, as calculated to disturb the general result. (See Table I., pp. 42, 43.)

From this table it appears, 1st. That the mean temperature of the most sickly quarters, whether winter, spring, summer, or autumn, was on the whole higher than that of the less sickly quarters. This difference is most obvious in the winter quarter, next in the summer quarter, and least in the spring quarter.

2d. That in the winter and spring the mean humidity of the atmosphere was on the whole less in the more sickly quarters than in the less sickly. In the summer and autumn quarters this difference is not remarkable.

3d. That the rainfall (including snow) was greater in the more sickly than in the more healthy winters. In the summers there was scarcely any difference in the mean rainfall of the sickly and more healthy quarters. In the spring and autumn the more healthy quarters were remarkable on the whole for a greater rainfall than the more sickly ones.

4th. That rain fell more frequently in the more sickly winters and summers than in the more healthy ones, but much less frequently in the more sickly than in the more healthy spring quarters.

On the whole it would appear that atmospheric temperature is the most important of the meteorological conditions mentioned, which influence the amount of general sickness. That in the winter a comparatively high temperature with atmospheric dryness, and much and frequent rain or snow, is calculated to render the season unhealthy; and conversely, that cold weather, with a moister atmosphere, and comparatively little rain and snow, is calculated to render the season healthy. That in the spring a moist atmosphere, with frequent and abundant rain, together with comparative lowness of temperature, is calculated to impart a healthy character to the season, while warmer and drier springs are on the whole less healthy. That in the summer season the healthiness or unhealthiness depend almost wholly upon the temperature. Lastly, that the healthiness or unhealthiness of the autumn also depends more upon its temperature than upon any other meteorological condition.

The exceptional year 1863, each quarter of which was unusually sickly, was remarkable for the comparatively high temperature of the winter and autumn quarters, and the atmospheric dryness of the whole year.

TABLE I.

WINTER QUARTERS.

Of greater Prevalence of Sickness.

Years.	New Cases of Sickness.	Mean Temperature.	Mean Humidity.	Rain in Inches.	Rainy Days.	Price of Wheat.		Price of Beef.	Price of Mutton.	Pauperism.
		°				s.	d.	d.	d.	
1859	4,004	43·3	83	2·55	33	40	8	5¾	5⅞	865,818
1860	6,640	38·9	82	3·80	52	44	5	5⅛	5¾	835,787
1862	6,118	40·6	86	5·73	43	60	1	5⅛	5⅝	948,198
1864	6,174	38·2	82	4·27	37	40	4	5½	6¼	995,334
1866	6,599	41·2	83	9·55	51	45	6	5⅝	6⅝	898,948
Mean -	5,907	40·4	83	5·18	43·2	46	2	5⅜	6	908,817

Of less Prevalence of Sickness.

Years.	New Cases of Sickness.	Mean Temperature.	Mean Humidity.	Rain in Inches.	Rainy Days.	Price of Wheat.		Price of Beef.	Price of Mutton.	Pauperism.
		°				s.	d.	d.	d.	
1857	3,167	36·3	85	3·79	35	56	10	5¾	6¼	912,547
1858	2,998	37·9	81	3·41	20	46	5	5¼	5⅞	974,017
1861	5,689	39·7	89	4·96	40	55	1	6	7¼	889,942
1865	5,780	36·6	82	5·94	45	38	4	5¾	6¼	955,700
Mean -	4,408	37·6	84	4·52	35·0	49	2	5¾	6⅜	933,051

SPRING QUARTERS.

Of greater Prevalence of Sickness.

Years.	New Cases of Sickness.	Mean Temperature.	Mean Humidity.	Rain in Inches.	Rainy Days.	Price of Wheat.		Price of Beef.	Price of Mutton.	Pauperism.
1859	3,599	54·2	77	6·40	29	47	3	5⅝	5⅞	819,560
1861	5,619	51·6	81	4·73	30	54	9	5⅜	6¼	831,587
1864	5,916	53·5	73	3·48	22	39	7	5¼	6⅛	908,542
1865	5,937	56·3	72	7·24	24	40	6	5¾	7⅜	901,862
1866	6,411	52·9	75	8·00	35	46	6	5⅞	7	857,796
Mean -	5,476	53·7	76	5·97	28·0	45	8	5½	6½	863,869

Of less Prevalence of Sickness.

Years.	New Cases of Sickness.	Mean Temperature.	Mean Humidity.	Rain in Inches.	Rainy Days.	Price of Wheat.		Price of Beef.	Price of Mutton.	Pauperism.
1857	2,889	54·3	76	4·06	31	56	9	5⅝	5¾	851,525
1858	3,287	54·7	72	5·07	30	44	1	5⅛	5½	871,512
1860	5,112	50·5	80	10·36	49	52	8	5¾	6½	799,434
1862	5,552	53·1	82	7·61	46	56	8	5	6	909,721
Mean -	4,210	53·1	77	6·77	39	52	6	5¼	5¾	858,048

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TABLE I.—*continued.*

SUMMER QUARTERS.

Of greater Prevalence of Sickness.										Of less Prevalence of Sickness.									
Years.	New Cases of Sickness.	Mean Temperature.	Mean Humidity.	Rain in Inches.	Rainy Days.	Price of Wheat.	Price of Beef.	Price of Mutton.	Pauperism.	Years.	New Cases of Sickness.	Mean Temperature.	Mean Humidity.	Rain in Inches.	Rainy Days.	Price of Wheat.	Price of Beef.	Price of Mutton.	Pauperism.
		°				s. d.	d.	d.				°				s. d.	d.	d.	
1857	3,610	63·3	77	5·73	30	59 11	5⅜	5¾	812,015	1858	3,514	61·0	74	5·39	29	44 7	5¼	5½	812,498
1859	4,133	62·8	73	7·10	33	44 0	5¼	5¾	783,449	1860	4,785	56·3	85	9·12	52	59 1	5⅝	6⅜	769,360
1861	6,269	60·4	78	4·20	43	52 1	5⅜	5⅞	805,581	1862	3,838	60·2	81	5·75	33	56 10	5½	6⅛	909,506
1866	7,841	58·7	80	7·93	45	51 0	6⅛	6¾	838,508	1864	5,932	59·4	71	4·37	24	42 3	5½	6¼	855,039
										1865	5,907	62·5	75	6·41	29	43 3	5¾	7½	836,761
Mean -	5,463	61·3	77	6·24	37·7	51 9	5½	6	809,888	Mean -	5,195	59·9	77	6·20	33·4	49 2	5½	6¼	836,632

AUTUMN QUARTERS.

Of greater Prevalence of Sickness.										Of less Prevalence of Sickness.									
Years.	New Cases of Sickness.	Mean Temperature.	Mean Humidity.	Rain in Inches.	Rainy Days.	Price of Wheat.	Price of Beef.	Price of Mutton.	Pauperism.	Years.	New Cases of Sickness.	Mean Temperature.	Mean Humidity.	Rain in Inches.	Rainy Days.	Price of Wheat.	Price of Beef.	Price of Mutton.	Pauperism.
1858	4,037	43·5	87	3·11	31	41 9	5¼	5½	826,655	1857	3,130	47·4	92	5·56	23	52 0	5⅜	5¾	859,756
1861	5,749	46·4	88	7·23	35	59 3	5⅛	5¾	844,429	1860	5,305	42·8	89	4·59	35	56 9	4⅞	5¾	788,838
1862	6,421	45·6	89	7·04	40	48 2	5⅛	6	1,040,156	1859	3,350	43·0	87	7·18	48	43 4	5¼	5¾	793,391
1866	6,599	46·5	87	5·36	41	56 8	5⅞	6⅜	868,291	1864	5,929	43·6	82	4·13	29	38 5	5 6/8	6¼	900,201
										1865	5,823	46·1	88	8·92	46	44 10	5⅝	6⅞	854,295
Mean -	5,701	45·5	88	5·68	36·7	51 5	5¼	5⅞	894,882	Mean -	4,707	44.6	88	6·07	36·2	47 0	5¼	6	839,296

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In 1867 the sickly winter was cold and comparatively dry, the spring after April had closed warm, the summer not hot until towards its close, and the autumn comparatively cold.

Last year, which was without parallel for sickliness in all the 12, was without parallel also for its uniformly high temperature, little rainfall, and atmospheric dryness. It was only in the latter part of October and in November that the mean temperature fell for any number of consecutive weeks below the average of the season. The average price of wheat was 72*s.* in the winter, 61*s.* in the spring, and 59*s.* in the summer; trade was depressed and pauperism excessive. No wonder, with this accumulation of causes, that the sickness of the year was so great.

The fluctuations of general sickness from week to week are mainly dependent upon the variations of temperature and the occurrence of drought or rainfall. An examination of the diagrams will show that commonly a rise of mean temperature in any week above that of the previous week is associated with an increase of general sickness, while a fall of mean temperature is commonly associated with a reduction in the quantity of general sickness. The greater the extent of these rises and falls the more certain on the whole is the occurrence of the associated normal alteration in amount of sickness. This variation of sickness with fluctuations in temperature is more decided in the colder than in the warmer seasons of the year. It is a subject which I have discussed so fully elsewhere (Med. Chir. Trans., vols. l. and li.), that I need say no more about it here. There are, however, two periods of the year when the rule ceases to apply. One of these is in the spring of the year, when the mean temperature begins permanently to rise above 40°, and the other in the end of the summer, when the temperature usually falls with more or less rapidity below 59°, with considerable increase in the atmospheric humidity. With respect to drought and rainfall, the examination of the diagrams seems to show that, whatever their operation may be on the whole upon the absolute amount of sickness, the first effect of rainfall is to reduce the number of new applicants for relief of sickness, and of absence of rain to increase their number. On analysing tables which I have constructed for the seven years, 1859 to 1865, I find that increase of sickness apparently occurred in 61 per cent. of the weeks in which there happened an entire absence of rainfall; that in weeks in which less than half an inch of rain fell decrease of sickness occurred in only 46 per cent., in weeks in which half an inch and less than one inch fell decrease of sickness happened in 53 per cent., and when more than one inch fell decrease of sickness happened in 61 per cent. The absence of rain and the occurrence of rain both operated more effectually in their several directions when associated with a fall of mean temperature than when associated with a rise.

Diseases of the Organs of Respiration.

Under this term I have grouped together bronchitic and catarrhal affections, asthma, pneumonia, and pleurisy. Not but that the meteorological conditions promotive of these several kinds of attack may be different, but because in the kind of practice from which the data of sickness are taken I find that some of them are not clearly distinguished from others. This is especially the case with the inflammatory diseases of the chest in infants. I exclude phthisis.

The total number of cases of respiratory disease recorded during the

12 years is 47,857. They were distributed among the several years as follows:—

In 1857	-	2,490 cases,	or 19·4	per cent.	of all cases.
„ 1858	-	2,903 „	20·9	„	„
„ 1859	-	2,520 „	16·7	„	„
„ 1860	-	4,043 „	18·5	„	„
„ 1861	-	3,331 „	14·2	„	„
„ 1862	-	3,999 „	16·7	„	„
„ 1863	-	4,439 „	16·6	„	„
„ 1864	-	4,128 „	17·1	„	„
„ 1865	-	4,088 „	17·4	„	„
„ 1866	-	4,771 „	17·3	„	„
„ 1867	-	5,346 „	19·5	„	„
„ 1868	-	5,799 „	17·7	„	„

As regards the distribution of these diseases on the average throughout the year, it is observable on Diagram 25 that they form one wave, which rises rapidly from the end of the summer during a few weeks, and after attaining its climax subsides through the winter and spring with remarkable deliberation. The following exhibits the distribution of these diseases through the several months and quarters per 100 cases on the average of the 12 years:—

In January -	12·8		
„ February -	10·9	Winter quarter -	34·1 cases.
„ March -	10·4		
„ April -	8·6		
„ May -	6·5	Spring quarter -	20·4 „
„ June -	5·3		
„ July -	4·2		
„ August -	4·0	Summer quarter -	13·5 „
„ September -	5·3		
„ October -	8·9		
„ November -	12·2	Autumn quarter -	32·0 „
„ December -	10·9		
	100·0		100·0

It is certain that 10·9 per cent. do not represent the full proportion of December cases, on account of the fallacy previously alluded to. Probably the December cases, if the necessary correction were made, would be equally numerous with the January cases, and thus the autumn would come at least to equal the winter quarter in the prevalence of this class of maladies. It will, therefore, be a fair statement to make that these diseases are at the lowest ebb in the months of July and August; that they begin to prevail in the month of October, and attain their maximum of prevalence in December or January; and then that a gradual, slow, but regular decline takes place through the succeeding months of winter and spring. On the average of the 12 years, the largest number of cases was recorded in the second week of January, and the smallest in the first week in August.

On looking at Diagram 25, it will be observed how very closely the line of general sickness follows that of the respiratory diseases through the year. The correspondence would apparently be almost complete, were it not for the disturbance occasioned by the cropping up of diarrhœal affections in the later spring and in the summer months. It

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is this disturbance which evidently occasions the small summer wave in the line of general sickness. The natural inference is, that the quantity of general sickness is chiefly dependent upon the quantity of respiratory disease prevalent at any time, except in the summer season.

I must observe, however, further, that the subsidence of respiratory sickness during the first two or three weeks of December is too great to be attributable to the social cause which lessens the number of new applicants for medical relief during the last weeks of that month, and it is apparently more closely connected with a habitual meteorological condition in these weeks which I shall allude to presently.

Comparing the line of respiratory diseases in Diagram 25 with the meteorological conditions indicated on the table, what strikes us most is the fact that it is almost the precise reverse of the line of mean temperature. It is true that the lines indicate that respiratory diseases are not at their minimum precisely at the time that the highest temperature of the year is attained, nor at their maximum precisely at the time that the lowest temperature is reached; in the former case the minimum is late by about three or four weeks, in the latter the maximum is late by about one week. But this only corresponds with what has been previously remarked about the greater readiness with which these maladies increase among the population than that with which they diminish. Looking for the reason of this general fact, it is difficult to disconnect it with the great difference in the character of the autumn and winter and spring as respects atmospheric humidity, as well as the greater rapidity with which the mean temperature falls from the summer during the autumn than that with which it rises from January to July. The autumn is quite unique in this respect, for not only does the humidity increase most rapidly during September and October, but the humidity of the autumn altogether is very much higher than that of the winter season. Hence it is, probably, that for the same mean temperatures there is in the autumn a larger quantity of respiratory disease than in the winter. Contrast, for instance, the months of November and March. Again, the second week in January was on the whole the most humid week of the whole winter, not the coldest week; and the first week in August was the least humid week of the summer, not the warmest.

I may now refer to the fall in the amount of respiratory diseases, observed in the average of years to occur in the first two or three weeks of December. During the first half or two-thirds of the autumn respiratory diseases were noticed to increase rapidly, and to attain a maximum of prevalence in the last week of November, the 47th week of the year, the mean temperature being 41·2°, and the mean humidity of the air 88. During the next two weeks a mean rise of a degree or a degree and a half of temperature was observed, and although with this the mean humidity was the same or higher, a smaller quantity of respiratory disease occurred on the whole in these weeks.

Table II. shows, for each quarter, the mean meteorological conditions existent in years in which diseases of this class were more or less prevalent. The teaching of the table is not to be mistaken, since it shows for each quarter or season of the year that the occurrence of diseases of this class is promoted by a comparatively low temperature for the season, a comparatively high atmospheric humidity, and much and frequent rain. The only apparent exceptions are, that in the winter quarters the atmospheric humidity was on the whole greater in those years in which respiratory diseases were less prevalent at this season, and that in the autumn there was rather more rain in the years

in which the respiratory diseases prevailed, less than in those in which they were more prevalent. (See Table II., pp. 48, 49.)

Sickness of this kind appears from the diagrams to fluctuate from week to week, increasing in weeks of rise, and decreasing in weeks of fall, of mean temperature. This relation to fluctuations of temperature is very strikingly exemplified in some of the diagrams, and is much more obvious in the colder than in the warmer months. Somewhere about the commencement of the second quarter of the year, when the mean temperature rises permanently above 45°, or thereabouts, this relation ceases for a time to be observable, and rises of mean temperature come to be immediately associated with diminution of respiratory sickness. Also, towards the close of the summer quarter, a similar exceptional occurrence is observed, when the mean temperature falls in the progress of the year below 60°, or thereabouts ; at this time, instead of the falls of temperature being associated with diminution, each weekly reduction of temperature is for a time associated with an increase of respiratory sickness. The exact temperature at which this event is met with varies from year to year ; when the summer has been hot it appears to occur at a higher mean temperature than when the previous summer has been cool. Contrast, for example, the lines of temperature and respiratory sickness towards the end of the summer season in 1868 with those in 1860 or 1862.

Diarrhœal Affections.

The affections thus grouped together are, ordinary diarrhœa, so-called dysentery, and ordinary summer cholera. Of these affections 16,456 cases have been recorded during the 12 years. They were thus distributed :—

In 1857	-	1,375 cases,	or 10·7	per cent.	of all cases.
„ 1858	-	868	„	6·3	„	„
„ 1859	-	1,322	„	8·7	„	„
„ 1860	-	721	„	3·3	„	„
„ 1861	-	1,395	„	5·9	„	„
„ 1862	-	950	„	3·9	„	„
„ 1863	-	1,340	„	5·0	„	„
„ 1864	-	1,205	„	5·0	„	„
„ 1865	-	1,325	„	5·6	„	„
„ 1866	-	2,586	„	9·4	„	„
„ 1867	-	1,341	„	4·9	„	„
„ 1868	-	2,028	„	6·1	„	„

For the most part then in the years in which respiratory diseases have been proportionally to all sickness less prevalent, diarrhœal affections have been more prevalent. The years 1863, 1866, and 1868 were years in which, however, both respiratory diseases and diarrhœal affections, together with the general sickness, gave high numbers.

The Diagram 25 shows that although diarrhœal affections are met with in practice all the year round, yet the cases only become abundant as the spring draws to a close, during the summer, and the early part of the autumn. Still the following monthly statement of the prevalence of these affections on the mean of 12 years shows that there is a regular wave commencing from the coldest season of the year, rising pretty steadily, but very gradually, to the middle of spring, when the rapidity of increase becomes greater, almost week by week, until the summit of the wave is attained. In like manner these affections diminish rapidly at first, but after about the middle of autumn slowly and steadily to a

TABLE II.—RESPIRATORY DISEASES.

WINTER QUARTERS.

Of greater Prevalence of Respiratory Diseases.						Of less Prevalence of Respiratory Diseases.					
Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
		°		Inches.				°		Inches.	
1860	1,611	38·9	82	3·80	52	1857	782	36·3	85	3·79	35
1863	1,447	42·5	83	4·08	35	1858	925	37·9	81	3·41	20
1864	1,518	38·2	82	4·27	37	1859	946	43·3	83	2·55	33
1865	1,450	36·6	82	5·94	45	1861	1,098	39·7	89	4·96	40
1866	1,586	41·2	83	9·55	51	1862	1,307	40·6	86	5·73	43
1867	2,002	38·5	83	6·29	51	1868	1,560	41·1	82	6·52	46
Mean -	1,602	39·3	83	5·66	45	Mean -	1,103	39·8	85	4·49	36

SPRING QUARTERS.

Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
1859	554	54·2	77	6·40	29	1857	385	54·3	76	4·06	31
1860	791	50·5	80	10·36	49	1858	466	54·7	72	5·07	30
1863	922	52·6	77	5·99	34	1861	674	51·6	81	4·73	30
1866	1,115	52·9	75	8·00	35	1862	779	53·1	82	7·61	46
1868	1,385	55·1	74	4·22	21	1864	806	53·5	73	3·48	22
						1865	841	56·3	72	7·24	24
						1867	919	54·3	77	6·27	39
Mean -	953	53·1	77	6·99	33	Mean -	695	54·0	76	5·49	31

TABLE II.—*continued.*

SUMMER QUARTERS.

Of greater Prevalence of Respiratory Diseases.						Of less Prevalence of Respiratory Diseases.					
Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
		°		Inches.				°		Inches.	
1860	534	56·3	85	9·12	52	1857	359	63·3	77	5·73	30
1862	613	60·2	81	5·75	33	1858	342	61·0	74	5·39	29
1863	706	59·1	74	5·18	27	1859	310	62·8	73	7·10	33
1866	652	58·7	80	7·93	45	1861	505	60·4	78	4·20	43
1867	666	59·7	78	11·40	35	1864	512	59·4	71	4·37	24
1868	920	64·1	70	4·40	23	1865	504	62·5	75	6·41	29
Mean -	681	59·7	78	7·29	35	Mean -	422	61·6	75	5·53	31

AUTUMN QUARTERS.

Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
1858	1,170	43·5	87	3·11	31	1857	964	47·4	92	5·56	23
1860	1,107	42·8	89	4·59	35	1859	710	43·0	87	7·18	48
1862	1,300	45·6	89	7·04	40	1861	1,054	46·4	88	7·23	35
1863	1,364	47·3	86	4·48	34	1864	1,292	43·6	82	4·13	29
1867	1,759	43·1	87	4·52	37	1865	1,293	46·1	88	8·92	46
1868	1,934	45·8	87	8·61	48	1866	1,418	46·5	87	5·36	41
Mean -	1,439	44·7	88	5·39	37	Mean -	1,121	45·5	87	6·39	37

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minimum of cases. The distribution of 100 cases through the year may be thus represented month by month:—

In January -	- 2·4	Winter quarter -	7·9 cases.
„ February -	- 2·7		
„ March -	- 2·8		
„ April -	- 3·0	Spring quarter -	14·3 „
„ May -	- 3·8		
„ June -	- 7·5		
„ July -	- 21·1	Summer quarter -	63·4 „
„ August -	- 27·5		
„ September	- 14·8		
„ October -	- 7·5	Autumn quarter -	14·4 „
„ November -	- 4·1		
„ December -	- 2·8		
	100·0		100·0

The spring and autumn then stand on about the same level as to the prevalence of diarrhœal affections, the winter quarter presenting only about half as many cases as either of them. The smallest number of cases was met with on the whole in the first week of the year, and, on the average of the 12 years, the coldest week of all the year. With almost complete regularity the cases increased in number week by week, until from a weekly average of 6·6 cases a weekly average of 91·8 cases was reached in the 30th week of the year, the last week in July. And then, following the line of average diarrhœa, a lessening in the number of cases occurred during two weeks, after which, in the 33rd week, the third week in August, a further rise took place, and the maximum of the year was attained. The regular diminution of diarrhœa succeeded. Now this order of occurrences gives to the summit of the average diarrhœal wave in Diagram 25 a remarkable shape, resembling the vertical section of the crater of a volcano, of which one margin is higher than the opposite. It is a fair representation of an occurrence which the annual diagrams show to have been very common in the course of summer diarrhœa, for the diarrhœal wave-line of most years exhibits more or less of this peculiar form of summit. The number of weeks intervening between the two elevated points is not always the same, nor is the relative height of these points always the same; but there is nearly always some indication more or less marked of a maximum, or apparent maximum, being attained, then of a lessening of diarrhœa, and then of a second real or apparent maximum of cases. It is well seen in the diagrams for 1857, 1858, 1861, 1863, 1864, 1865, and 1867.

I must here draw attention to the regularity with which the line of general sickness follows that of diarrhœa in the 25th diagram, from the 24th to the 37th week.

The line of diarrhœa, however, does not exactly follow that of mean temperature. The lowest part of the line indeed corresponds with the lowest weekly temperature of the year, and it rises as the mean temperature on the whole rises, and as the atmospheric humidity on the whole lessens, but very slowly and gradually. Nothing like an abrupt rise happens until the line of mean temperature marks an elevation of atmospheric warmth to 60° and upwards, in the 25th week. In like manner, during the decline of diarrhœa, the weekly diminution of this kind of sickness ceases to be rapid and becomes smaller, and the diminution more gradual in the 38th week, on the falling of the mean temperature

materially below 60°. In the interval between these periods the rise on the one side and the fall on the other is observed to be considerable week by week. And now I must direct attention to what I may term the two apexes of the cone formed by the diarrhœal line, or to what may be termed the two maximums of diarrhœa. It is to be observed that the first does not correspond with the week of highest mean temperature of the year, but points to a period two weeks later. Following now the line of mean temperature, it appears that on the whole (although it remains high) some reduction occurs in the temperature of the three or four weeks succeeding that of highest temperature, and that then a second rise to a less extent takes place prior to the final fall of the mean temperature of the year to 60° and under. This fact offers some explanation of the peculiar shape of the top of the diarrhœal wave, the second apex corresponding with the week following that of the second rise of temperature. The lesson these facts seem to teach us is this, that a high temperature does not produce diarrhœa by an immediate action upon the system, but by some more gradual process, one probably not confined to the people under its influence, but extended to their surroundings also—the soil, the water, and perhaps also the food. The diagrams for individual years may be appealed to to illustrate the same truths as the diagrammatic summary teaches. It is to be further observed that the top of the diarrhœal wave corresponds also pretty nearly with the period of greatest atmospheric dryness, although not with that of least average summer rainfall.

Table III. exhibits the relation between diarrhœa and the more important meteorological conditions present in seasons of greater or less prevalence of this class of affections. I omit the year 1866 as altogether exceptional—I shall refer to it again—and shall confine myself to the period from June to October, as embracing that which is alone important for our purpose. (See Table III., pp. 52, 53.)

The severity with which the diarrhœal season sets in in the month of June depends clearly upon the heat and dryness of the atmosphere; similar conditions governing also the prevalence of diarrhœal affections throughout the summer quarter. It is remarkable that as diarrhœa approaches the period of its quiescence in October, the months in which it prevailed most were those in which this season of the year was most strongly characterized on the whole by atmospheric humidity and rainfall.

The hot and dry year 1868 illustrates well the meteorological conditions favourable to the prevalence of diarrhœa. Cases of diarrhœa were unusually numerous from the very beginning of the spring quarter, and in the course of the summer it attained a degree of prevalence (1,309 cases) only comparable with that of the summers of 1857 and 1859, and approaching nearest of all to that of the cholera season of 1866.

The exceptional cholera year 1866 deserves particular notice, chiefly because the summer diarrhœa, the recorded cases of which amounted in the three months July, August, and September to 1,879, did not correspond to the meteorological conditions existent during its prevalence. Neither did the summit of the diarrhœal wave, as will be seen on looking at Diagram 19, correspond with that of the wave of epidemic cholera as it presented itself in this district. The mean temperature of the 13 weeks of summer was positively low, viz., 58·7°; that of the four weeks of July being 61·5°, of the four weeks of August 58·9°, and of the five weeks of September 56·9°. The humidity of the atmosphere also was great for the season, and the rainfall considerable. It was therefore impossible to fail in recognizing in this season the operation of a cause other than the ordinary meteorological causes of summer diarrhœa,

TABLE III.

MONTH of JUNE.

Seasons of greater Prevalence of Diarrhœa.						Seasons of less Prevalence of Diarrhœa.					
Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
		°		Inches.				°		Inches.	
1857 -	106	61·3	74	2·28	12	1860 -	60	54·1	83	6·25	25
1858 -	136	64·1	67	1·24	5	1861 -	110	58·8	80	1·92	16
1859 -	100	61·4	78	2·67	11	1862 -	74	56·5	80	2·02	19
1865 -	202	60·0	70	2·52	6	1863 -	98	57·4	76	3·96	15
1868 -	246	61·5	70	1·85	8	1864 -	104	56·7	73	1·31	11
						1867 -	102	60·0	76	2·47	11
Mean -	158	61·6	72	2·11	8	Mean -	91	57·2	78	2·98	16
MONTHS of JULY, AUGUST, and SEPTEMBER.											
1857 -	932	63·3	77	5·73	30	1858 -	458	61·0	74	5·39	29
1859 -	946	62·8	73	7·10	33	1860 -	298	56·3	85	9·12	52
1861 -	888	60·4	78	4·20	43	1862 -	423	60·2	81	5·75	33
1863 -	889	59·1	74	5·18	27	1864 -	751	59·4	71	4·37	24
1867 -	844	59·7	78	11·40	35	1865 -	699	62·5	75	6·41	29
1868 -	1,309	64·1	70	4·40	23						
Mean -	968	61·6	75	6·33	31	Mean -	525	59·9	77	6·20	33

TABLE III.—*continued.*

MONTH of OCTOBER.

Seasons of greater Prevalence of Diarrhœa.						Seasons of less Prevalence of Diarrhœa.					
Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
		°		Inches.				°		Inches.	
1857 -	75	52·2	92	3·93	9	1860 -	70	50·2	87	1·05	10
1858 -	58	50·8	85	1·16	9	1861 -	77	56·5	89	0·95	11
1859 -	53	51·0	88	2·67	16	1863 -	81	52·9	86	1·54	14
1862 -	131	53·9	88	4·17	15	1864 -	71	50·9	77	1·03	5
1865 -	145	51·3	87	5·18	16	1867 -	86	49·1	87	1·51	16
						1868 -	69	49·4	87	2·29	14
Mean -	92	51·9	88	3·42	13	Mean -	75	51·5	85	1·39	11

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producing the enormous amount of diarrhœa observed;—for the cases recorded upon the books, numerous as they were, did not represent anything like all that were admitted under treatment. A consideration of the temperature of the season week by week will put this in a still clearer light. In the fourth week of June the mean temperature was 58·1°, and in the fifth week it suddenly rose to 66·3°; in the week following it fell 10 degrees, to rise in the second week of July 12 degrees, to 68·2°, the highest weekly mean of the year. For four or five weeks after this it progressively fell to 58·0°. The month of June was not remarkable for diarrhœa, and gave no promise, had not cholera been anticipated, of a heavy diarrhœal epidemic. In the fifth week of June only 28 cases were recorded; in the first week of July there were 55 cases, and they increased week by week thus, 43, 99, 115, 165, 272, 313, the last number being attained in the third week of August, that is, five weeks after the maximum temperature of the year had been reached, the steady increase of cases having gone on concurrently with a steady decline of mean temperature below 60°. Our maximum of weekly cases of diarrhœa was attained on the second week after the most fatal week of cholera in London, which was also the week on which the largest number of cases of the disease was observed in Islington. Diarrhœa then increased as cholera declined.

Measles.

The number of cases of measles recorded during the 12 years was 5,501. It is thus made up:—

In 1857	- -	221	cases, or	17·2	per 1,000 of all cases.	
„ 1858	- -	416	„	30·0	„	„
„ 1859	- -	328	„	21·7	„	„
„ 1860	- -	531	„	24·3	„	„
„ 1861	- -	280	„	12·0	„	„
„ 1862	- -	653	„	27·2	„	„
„ 1863	- -	322	„	12·0	„	„
„ 1864	- -	713	„	29·7	„	„
„ 1865	- -	200	„	8·5	„	„
„ 1866	- -	813	„	29·6	„	„
„ 1867	- -	328	„	11·9	„	„
„ 1868	- -	696	„	21·2	„	„

What strikes a person first in looking at this list is, that, in the limited district to which these figures relate, measles was epidemic regularly every second year, the only exception being that 1859 did not exhibit the full subsidence of the disease which this observation would have led one to anticipate. I do not gather from the death register that the years of greater prevalence of measles here were years of greater prevalence throughout the kingdom. It would seem as if an epidemic of measles so far exhausted the susceptibility of the population here that it did not recover itself for two years. There was nothing very decidedly in common in the meteorological conditions either of the epidemic years or of the years of less prevalence of the disease. Contrast for example the cold wet year 1860 and the excessively hot and dry year 1868. It would be interesting to know whether in other limited communities a similar observation has been made. It is remarkable also that the percentage of all cases of sickness was nearly the same number in four out of the six epidemic years, viz., 1858, 1862, 1864, and 1866. All that can be said is that on the whole, putting out 1868, the years of greater prevalence of measles were rather cooler years than those of less prevalence.

Diagram 26 exhibits the line of measles in accordance with our 12 years' experience of its distribution through the several seasons of the year. It forms two waves in the year, the one culminating in the latter part of spring, the other at the end of autumn. Of these the earlier is the more considerable wave. Assuming the yearly occurrence of 100 cases, the normal distribution of measles may be represented as follows :—

In January	7·1	Winter quarter	19·3 cases.
" February	6·0		
" March	6·2		
" April	6·5	Spring quarter	30·4 "
" May	11·3		
" June	12·6		
" July	10·4	Summer quarter	25·8 "
" August	7·5		
" September	7·9		
" October	6·8	Autumn quarter	24·5 "
" November	8·3		
" December	9·4		
	100·0		100·0 "

The smallest number of cases occurred in the month of February, the largest number in June. The spring wave of the epidemic rises with some suddenness in May, but subsides more gradually to October. Altogether the spring quarter was that in which measles prevailed most ; it was less prevalent in summer and autumn, and least so in the winter quarter.

Referring to the diagrams, we find that out of the six epidemic years, 1858, 1860, 1862, 1864, 1866, and 1868, there were four in which the largest number of cases occurred in the spring quarter, and only two, 1862 and 1868, in which the largest number occurred in the autumn quarter ; still in 1862 the largest monthly number of cases occurred in May and June, and the next largest number in December. In 1868 the largest number of cases occurred in December.

In the non-epidemic years, 1857, 1859, 1861, 1863, 1865, 1867, spring was not so specially favoured. In two of these years, 1859 and 1865, the largest number of cases occurred in the winter quarter. In 1859 spring and summer were little less troubled with measles, the largest monthly number of cases occurring in May and September. In 1865 the winter measles was a mere prolongation of the autumnal epidemic of 1864 into January and February. The epidemic of 1866 began in December of 1865, the disease having been in abeyance from March to that month. In two of these years, 1857 and 1867, the greatest number of cases of measles occurred in the autumn. When this happened the disease abated in the succeeding winter. In only one of these years, 1863, did the largest number of cases occur in the spring, and in only one, 1861, did the largest number occur in the summer season.

In five out of the six epidemic years, not only was there a large number of cases forming a wave of measles culminating in the spring and early part of summer, but there was a considerable autumnal wave also. The exceptional year was the cold wet year 1860, when the autumnal wave did not occur at all. Only in two out of these five years was the autumnal wave greater than the spring wave, namely in 1862 and 1868. In 1862 it was very slightly greater, the greatest monthly number of cases occurring in June and July. In 1868 the disease steadily in-

creased quarter by quarter as the year progressed, the summer cases exceeding the spring slightly, and the winter greatly exceeding either. The largest number of cases happened in November and December.

In four out of six of the non-epidemic years there was an autumnal wave greater than the spring wave, viz., in 1857, 1861 (slightly), 1865, and 1867 (considerably).

Although it must be concluded that on the whole measles is more abundant in the spring quarter, yet the occurrence of an autumnal wave must be regarded as a more constant event.

There were four years out of the 12, viz., 1861, 1866, 1867, and 1868, in which measles was more abundant in the summer than in the spring quarter. In 1861 the largest number of cases occurred in August; in 1866 about an equal proportion of cases happened in June, July, August, and September; in 1867 there were more cases in July and August than in June; and in 1868 the disease, which prevailed considerably in May, declined during June, July, and August, to increase in September up to the end of the year.

In searching for the meteorological conditions which occasion the waves of measles, which promote its increase or its decline, we may first of all consider the habitual meteorological conditions of those seasons which our 12 years' experience teach us are favourable to the spread of the disease, or the reverse.

And here we must recollect that the law by which contagious diseases spread in a population is, that when once started under favourable conditions of weather and season, another element of rapid extension comes into play, namely, the growing increase in the number of foci of contagion; so that so long as the conditions of weather and season are not absolutely unfavourable to the life and development of the morbific germs, the disease increases in extent, and does not lessen until either the susceptibility of the population is exhausted, or conditions of season come about absolutely unfavourable to the spread of the malady. Moreover in estimating the conditions of weather favourable to measles, or the reverse, we must bear in mind that this disease has an incubation of about 14 days, and make an allowance accordingly. I must give this as an instruction in the reading of the diagrams so far as measles is concerned. In the decline of an epidemic we must similarly bear in mind the progressive diminution of the foci of contagion. Now referring to my records of the 12 years, I find that on the average measles began to assume its epidemic character in the 18th week of the year, that is, in the first week of May. The average weekly meteorological conditions and average weekly number of cases of measles for each week about this time were as follows:—

—	Average of new Cases Two Weeks later.	Mean Temperature.	Mean daily Range of Temperature.	Mean Humidity.	Mean Rainfall.	Rainy Days in 12 Years.
		°	°		Inches.	
12th week	5·2	40·9	15·0	81	0·41	33
13th "	7·2	45·4	15·8	81	0·38	45
14th "	6·0	46·6	17·4	82	0·38	34
15th "	8·8	46·6	17·4	81	0·44	40
16th "	11·0	48·2	20·3	75	0·14	19
17th "	11·5	49·1	18·9	79	0·50	32
18th "	14·1	49·2	19·2	74	0·22	23

From which we may gather that the conditions most favourable to the outbreak of the spring epidemic of measles are, the rise of the mean tem-

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perature to 48° or upwards, with an increase of daily range to 20° and upwards, combined with a lowering of the atmospheric humidity to 75° and under, the rainfall and the number of wet days being at the same time much below the average of the whole season. It is worthy of notice that the meteorological averages of the 17th week exhibited a return towards those of the 15th, and that with this the average of cases of measles was nearly stationary. Again, that on the average temperature rising in the 18th week above that of the 16th, with a reduction in the humidity and rain, measles rose again above the average of the 16th week.

Again, the average number of cases of measles began to fall permanently in the 28th week, that is, in the second week of July. The average of cases and meteorological conditions about this time were as follows :—

—	Average of new Cases Two Weeks later.	Mean Temperature.	Mean daily Range of Temperature.	Mean Humidity.	Mean Rainfall.	Rainy Days in 12 Years.
		°	°		Inches.	
22d week	14·8	57·8	21·1	76	0·82	33
23d „	13·3	58·5	20·5	78	0·63	32
24th „	12·3	58·8	21·8	74	0·35	26
25th „	13·2	60·2	22·0	75	0·47	32
26th „	12·1	60·4	20·7	74	0·48	32
27th „	10·1	59·9	21·5	74	0·40	29
28th „	8·0	63·6	23·7	73	0·23	17
29th „	9·0	63·5	20·2	73	0·59	30

From which it appears that the condition and the only condition which this table indicates, as concerned in the arrest of the spread of measles, is the rise of the temperature of the atmosphere above a mean of 60°.

And now for the autumnal epidemic. The first outbreak of this took place on the average of the 12 years in the 47th week of the year, that is, in the last week of November. The averages about this time are as follows :—

—	Average of new Cases Two Weeks later.	Mean Temperature.	Mean Daily Range.	Mean Humidity.	Mean Rainfall.	Rainy Days in 12 Years.
		°	°		Inches.	
42nd week	7·2	51·2	14·3	88	0·87	46
43rd „ -	8·6	48·8	14·1	89	0·54	35
44th „ -	8·2	46·7	14·8	88	0·47	41
45th „ -	11·0	43·0	13·1	87	0·30	24
46th „ -	10·7	41·6	12·7	88	0·49	30
47th „ -	12·3	41·2	12·4	88	0·44	34
48th „ -	8·6	42·2	10·3	88	0·44	40
49th „ -	10·1	42·9	10·9	90	0·46	42
50th „ -	7·4	41·5	9·2	88	0·35	36
51st „ -	9·0	40·8	10·4	86	0·28	29
52nd „ -	7·0	39·6	9·7	87	0·31	31
1st „ -	8·1	35·2	9·9	85	0·39	40
2nd „ -	5·5	37·4	10·3	87	0·63	41

This seems to show that the arrival of the temperature below 49° and especially to about 43°, with a diminution of range to about 13 degrees, and again (as in the spring) a small rainfall for the season, are the conditions which favour the outbreak of the autumnal epidemic.

The circumstances promotive of the decline of the autumnal epidemic are less obvious; all that appears clearly is, that it shows a manifest disposition to decline on the fall of the mean temperature below 42°.

Putting the characters of the two epidemic seasons together, I think we may conclude that—1. The conditions promotive of an outbreak of measles in any year are a temperature between 43° and 48°.—2. That a low atmospheric humidity and small rainfall assist materially in promoting an outbreak. Probably the higher humidity of the autumn than of the spring is one reason why ordinarily the autumnal epidemic is less extensive than the spring epidemic.—3. That a rise of mean temperature above 60° and a fall below 42° tend distinctly to arrest an epidemic.

Table IV. (pp. 59, 60) exhibits the leading meteorological condition of each quarter of the several years, dividing the quarters into those in which measles prevailed more or less. It seems to show—

1. That in the *winter* season a comparatively warm and dry atmosphere with excess of rainfall are conditions which favour the extension of measles among a population more than the opposite conditions.

2. That in the *spring* a comparatively cool season with atmospheric dryness and excess of rainfall promote the spread of the disease.

3. That in the *summer* measles spreads more when the atmosphere is comparatively cool and moist, with excessive and frequent rains.

4. That in the *autumn* a comparatively warm dry atmosphere with small rainfall is most favourable to the operation of the morbific cause.

These inferences, although at the first blush contradictory to those just enunciated, need not be regarded as actually so. The former may relate to the conditions favourable to the life and development of the germs, the latter to those which predispose a population, just as bad hygienic conditions generally would do, to suffer from the malady.

There is only one other point I need draw attention to in relation to the line of measles in the diagrams, and this is, that making the necessary fortnight's allowance (or thereabouts) for incubation, measles appears to have increased commonly after any great alteration of mean temperature, whether by way of increase or diminution. That is to say, one is led to expect from the experience of the 12 years, especially when an epidemic is due, that it will break out about a fortnight after the occurrence of a serious rise in the mean temperature of the year, and that in its progress an increase of cases may be anticipated in the second week following any considerable rise or fall of temperature. In the autumn, as the temperature of 48° is approached, the outbreak of the epidemic may be anticipated when a serious fall of mean temperature occurs.

There was among the 12 years one only in which measles pretty steadily increased quarter by quarter through the year, the autumnal epidemic being more serious than the spring epidemic. This was the year 1868; hence it is instructive. The spring epidemic broke out very suddenly in the 17th week of the year, that is, in the last week of April. There was some abatement in the month of August, but it burst out afresh and with severity in the middle of September, and was very severe as the year closed. Hence it will be desirable to exhibit in a table the corresponding meteorological conditions.

TABLE IV.

WINTER QUARTERS.

Of greater Prevalence of Measles.						Of less Prevalence of Measles.					
Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
		°		Inches.				°		Inches.	
1859 -	98	43·3	83	2·55	33	1857 -	59	36·3	85	3·79	35
1864 -	190	38·2	82	4·27	37	1858 -	64	37·9	81	3·41	20
1865 -	101	36·6	82	5·94	45	1860 -	75	38·9	82	3·80	52
1866 -	188	41·2	83	9·55	51	1861 -	63	39·7	89	4·96	40
						1862 -	35	40·6	86	5·73	43
						1863 -	69	42·5	83	4·08	35
						1867 -	53	38·5	83	6·29	51
						1868 -	55	41·1	82	6·52	46
Mean -	144	39·8	82	5·56	41	Mean -	59	39·4	84	4·83	40

SPRING QUARTERS.

Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
1858 -	149	54·7	72	5·07	30	1857 -	51	54·3	76	4·06	31
1860 -	260	50·5	80	10·36	49	1859 -	91	54·2	77	6·40	29
1862 -	207	53·1	82	7·61	46	1861 -	56	51·6	81	4·73	30
1864 -	322	53·5	73	3·48	22	1863 -	100	52·6	77	5·99	34
1866 -	206	52·9	75	8·00	35	1865 -	26	56·3	72	7·24	24
1868 -	177	55·1	74	4·22	21	1867 -	53	54·3	77	6·27	39
Mean -	220	53·3	76	6·45	33	Mean -	62	53·9	77	5·78	31

TABLE IV.—*continued.*

SUMMER QUARTERS.

Of greater Prevalence of Measles.						Of less Prevalence of Measles.					
Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
		°		Inches.				°		Inches.	
1858 -	89	61·0	74	5·39	29	1857 -	36	63·3	77	5·73	30
1859 -	91	62·8	73	7·10	33	1861 -	95	60·4	78	4·20	43
1860 -	130	56·3	85	9·12	52	1863 -	77	59·1	74	5·18	27
1862 -	196	60·2	81	5·75	33	1864 -	82	59·4	71	4·37	24
1866	283	58·7	80	7·93	45	1865 -	32	62·5	75	6·41	29
1868 -	197	64·1	70	4·40	23	1867 -	89	59·7	78	11·40	35
Mean -	164	60·5	77	6·61	35	Mean -	68	60·7	76	6·21	31

AUTUMN QUARTERS.

Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
1858 -	114	43·5	87	3·11	31	1857 -	75	47·4	92	5·56	23
1862 -	215	45·6	89	7·04	40	1859 -	48	43·0	87	7·18	48
1864 -	119	43·6	82	4·13	29	1860 -	66	42·8	89	4·59	35
1866 -	136	46·5	87	5·36	41	1861 -	66	46·4	88	7·23	35
1867 -	133	43·1	87	4·52	37	1863 -	76	47·3	86	4·48	34
1868 -	267	45·8	87	8·61	48	1865 -	41	46·1	88	8·92	46
Mean -	164	44·7	87	5·46	37	Mean -	62	45·5	88	6·32	36

—	No. of new Cases Two Weeks later.	Mean Temperature.	Mean Daily Range.	Mean Humidity.	Rainfall.	Rainy Days.
1868.		°	°		Inches.	
12th week	0	44·0	17·3	84	0·07	3
13th „ -	5	42·7	15·0	77	0·51	3
14th „ -	4	45·2	23·3	78	0·00	0
15th „ -	20	45·7	20·5	77	0·39	2
16th „ -	20	45·7	18·9	82	0·10	1
17th „ -	27	50·2	14·8	81	1·47	6
18th „ -	17	53·0	20·9	73	0·12	1
19th „ -	20	53·3	26·7	73	0·03	1
20th „ -	10	57·5	24·9	77	0·00	0
21st „ -	8	59·4	24·0	73	0·26	2
22nd „ -	22	59·2	23·0	77	*1·38*	3
23rd „ -	14	58·6	22·9	76	0·14	2
24th „ -	10	60·3	25·4	63	0·00	0
25th „ -	13	65·4	27·9	69	0·04	1
26th „ -	15	63·6	25·6	68	0·29	2
27th „ -	18	61·6	23·4	68	0·01	1
28th „ -	17	65·7	27·2	64	0·13	1
29th „ -	10	*70·7*	*27·8*	*64*	0·70	2
30th „ -	10	69·2	27·8	59	0·01	1
31st „ -	14	67·6	26·5	64	0·23	2
32nd „ -	18	69·8	24·7	65	0·14	1
33rd „ -	17	64·3	21·4	71	0·37	3
34th „ -	5	61·9	*12·2*	*87*	1·97	6
35th „ -	25	58·1	*19·4*	*71*	0·06	1
36th „ -	21	65·3	26·9	77	0·00	0
37th „ -	14	64·0	25·5	70	0·00	0
38th „ -	20	57·1	17·0	71	0.27	1
39th „ -	23	58·4	18·2	80	0·51	4
40th „ -	14	53·7	*12·3*	*85*	1·17	5
41st „ -	13	51·8	18·5	87	0·60	3
42nd „ -	15	49·7	20·1	88	0·03	2
43rd „ -	22	*42·6*	16·4	90	0·49	4
44th „ -	27	46·8	13·7	87	1·06	3
45th „ -	23	43·9	13·9	83	0·18	2
46th „ -	13	40·7	10·5	85	0·06	3
47th „ -	18	39·8	11·4	84	0.04	2
48th „ -	23	42·5	9·3	92	0·88	5
49th „ -	32	45·6	7·7	91	0·31	4
50th „ -	24	47·6	9·7	87	1·30	4

In studying this table it must be kept in mind that 1868 was a year in which an epidemic of measles was due, and had it not been for the remarkable temperature and drought of the spring and early summer, the epidemic would have prevailed, in all probability, chiefly in this season. As it was, these conditions seem to have checked its progress, and deferred the severity of the outbreak until the temperature fell to a point at which the morbific germs could be in circumstances to operate effectually upon the population whose susceptibility had not yet been exhausted. The outbreak commenced about a fortnight or three weeks after a period of remarkable absence of rain, the temperature having arrived midway between 43° and 48°, the range being about 20 degrees, and the humidity of the atmosphere for a short time having fallen to about 77. I have emphasized in the table some of the occurrences in certain weeks. In the 22nd week, after long drought, a heavy rainfall (comparatively) occurred, and measles rose a fortnight after from eight cases to 22 in the week. It subsided remarkably after the 24th week, in association with a remarkable rise of temperature with very unusual dryness of the atmosphere and lack of rain, and another decided subsidence took place

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in the 30th week; a fortnight after the mean temperature had attained the excessive height of 70·7° with a mean daily range of 27·8°, and a humidity of only 64, and this notwithstanding comparatively much rainfall in that week. Measles again underwent a remarkable fall in the 36th week from 17 cases to 5, the 34th week being distinguished from those before and succeeding it by a very high atmospheric humidity and an unusually small mean daily range for the season, and this again notwithstanding the heavy and continued rainfall. In the next week measles increased again on the reduction of the mean temperature below 60°, with greater range and a humidity of 71. In the 42nd week another remarkable reduction of measles occurred, following a curious and sudden reduction of range and increase of humidity, and again uninfluenced by the heavy and continued rainfall. The latter seems only to have operated in promoting the spread of measles in this year when not associated with a high atmospheric humidity. Measles again underwent a great increase, the commencement of the autumnal epidemic in the 45th week. In the 42nd the mean temperature first fell considerably below 50°. A temperature about or below 40° in the 46th or 47th weeks evidently checked its progress, but it recovered itself when in the 48th week the mean temperature again rose to or above 42·5°.

Scarlatina.

The number of cases of scarlatina recorded during the 12 years was 3,850. It is thus made up:—

In 1857 -	- 75 cases,	or 5·8	per 1,000	of all cases.
„ 1858 -	- 162	„ 11·7	„	„
„ 1859 -	- 426	„ 24·9	„	„
„ 1860 -	- 232	„ 10·6	„	„
„ 1861 -	- 247	„ 10·5	„	„
„ 1862 -	- 299	„ 12·4	„	„
„ 1863 -	- 630	„ 23·5	„	„
„ 1864 -	- 269	„ 11·2	„	„
„ 1865 -	- 292	„ 12·4	„	„
„ 1866 -	- 255	„ 9·2	„	„
„ 1867 -	- 524	„ 19·1	„	„
„ 1868 -	- 439	„ 13·4	„	„

It is observable that three non-epidemic years intervened between the epidemic years 1859 and 1863, and three again between the epidemic years 1863 and 1867. Last year, in all respects exceptional, was also marked by an epidemic of scarlatina, but of less extent than that in 1867. On the whole these epidemic years were years of comparatively high mean temperature and atmospheric dryness. Putting aside the epidemic years, the prevalence of scarlatina in the non-epidemic years did not differ very materially. The proportion of scarlatina to all cases of sickness differed very little in 1859 and 1863. In 1867, the fourth year from the last epidemic, the outbreak of scarlatina was on the whole less severe, perhaps in association with the comparatively low mean temperature of the year. 1868 should, in accordance with previous experience, have been a non-epidemic year; and in point of fact, although the cases were very numerous absolutely, the proportion borne to all cases of sickness was not much higher than that in 1862 and 1865. Probably the comparatively high absolute number was due to similar causes which occasioned the great general sickness among the poor last year, combined with the excessive heat and dryness of the first three quarters.

Diagram 26 exhibits the line of distribution of scarlatina through the

several seasons of the year, in accordance with our 12 years' experience. Scarlatina forms but one grand wave in the year.

Assuming the yearly occurrence of 100 cases, the following indicates the proportion of cases which occurred in the several seasons of the year :—

In January	6·5	Winter quarter, 17·7 cases.
„ February	6·8	
„ March	4·4	
„ April	5·7	Spring quarter, 17·3 „
„ May	5·6	
„ June	6·0	
„ July	9·1	Summer quarter, 29·9 „
„ August	8·6	
„ September	12·2	
„ October	14·5	Autumn quarter, 35·1 „
„ November	11·4	
„ December	9·2	
	100·0	100·0

The smallest number of cases occurred in the month of March, and the prevalence of the disease has been in our experience greater as the spring and summer advanced, until the month of October, in which the disease has been observed to be more prevalent than in any other. From October it has been observed to become less prevalent, through November, December, January, and February to March. Scarlatina, then, is a disease which attaches itself with very marked preference to the latter half of the year. It is curious that it should be about equally prevalent on the whole in months of such opposite characters as July and December.

Of the four epidemic years, 1859, 1863, 1867, and 1868, there were two, 1859 and 1867, in which the largest number of cases occurred in the autumn quarter ; in the other two years, 1863 and 1868, the largest number occurred in the summer quarter.

Of the eight non-epidemic years there were four, 1857, 1858, 1864, and 1865, in which the summer quarter exhibited the largest quantity of scarlatina ; three, 1861, 1862, and 1866, in which the greatest number of cases occurred in the autumn.

It would appear as if some preparation were made, or warning given, the year previous to an epidemic of scarlatina. Thus in 1858 scarlatina suddenly burst out in the month of September, with 51 cases in five weeks (14 having been recorded in August). It then subsided as the autumn proceeded, but still there was a considerable number of cases. It fell almost into abeyance in February and March of 1859, after which it increased quarter by quarter to the end of the year. The great outburst began in September. The last week of this month, with the whole of October and November, up to the last week of that month, embraced the worst period of the most extensive epidemic of the whole 12 years. It did not completely come to an end until the end of March 1860.

Again, the grand epidemic year 1863 was preceded by a sharp autumnal outbreak in 1862. Indeed, one may go so far as to regard this epidemic as extending without break from September 1862 to the end of 1863. The 1859 epidemic came to an end in April 1860 ; and with the exception of the ordinary increase of the disease which may be expected every summer and autumn, nothing remarkable was observed until the end of the summer of 1861. In September, October, and

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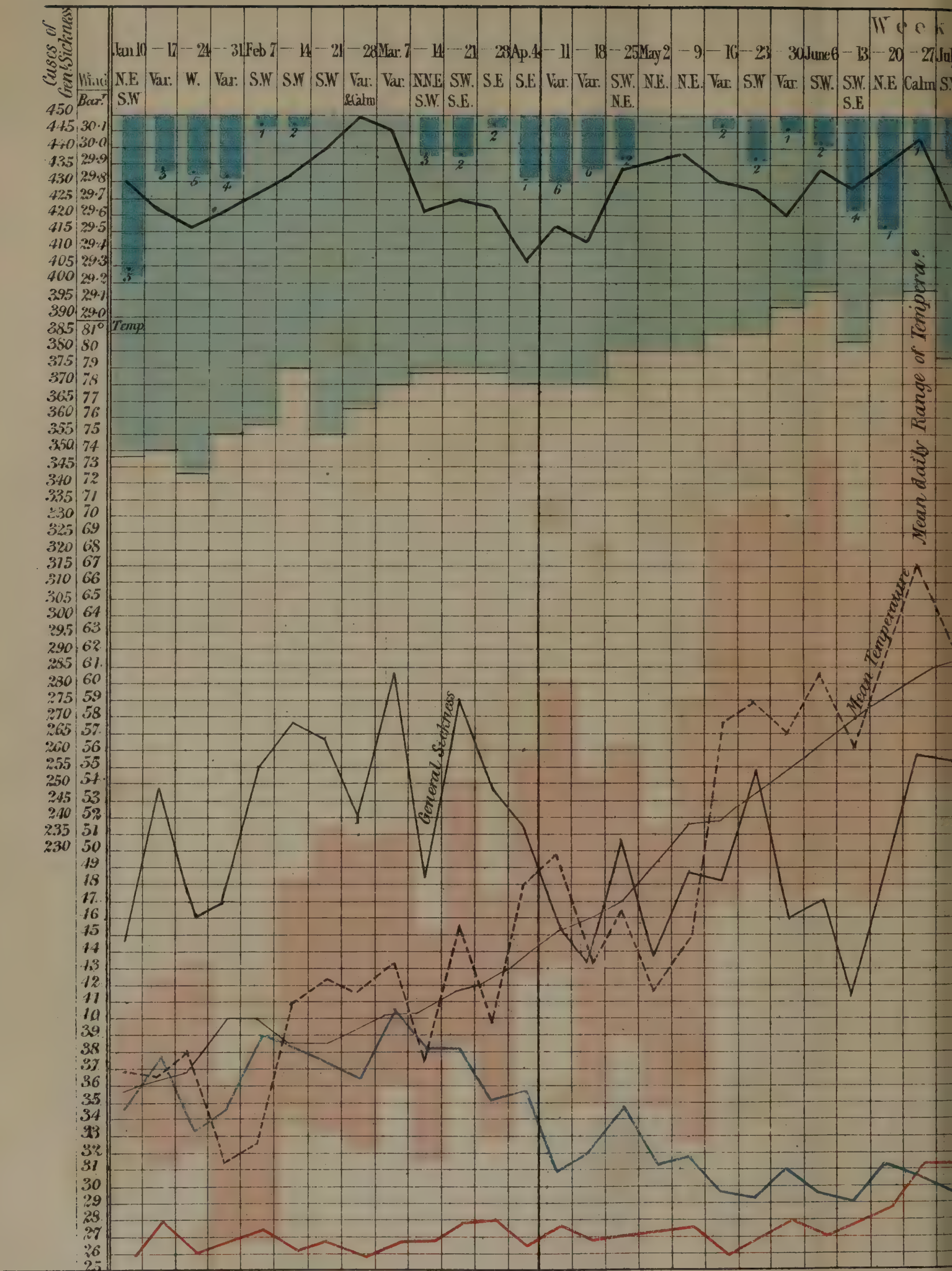
November a slight epidemic wave occurred, which extended, subsiding, however, through the winter of 1862. The disease almost died out in June, but gradually increased afterwards; and in September began the heavy epidemic which only terminated with the end of the next year, 1863. There was merely some little abatement of the epidemic violence at times during the winter and spring of 1863, but from July to October it exhibited its chief activity.

The epidemic which we have last experienced commenced with an outburst of the disease in the autumn of 1866. It subsided a little during the winter quarter of 1867, but then increased from April, month after month, until October, upon which month the chief violence of the epidemic was expended. A partial subsidence of the disease then commenced, continuing through January, February, and March 1868. The spring months of this year, however, saw the epidemic reviving; and it was as severe, to say the least, in the spring and summer of 1868 as in those of 1867. After September the epidemic declined, and only 99 cases were recorded in the autumn quarter of 1868, against 222 in the corresponding period of the previous year.

Unlike measles, scarlatina has so brief an incubation that it may be disregarded practically in any consideration of its meteorological associations. Following the same method of inquiry that we pursued with measles, we may study, on the following table, first of all, the conditions which, on the average of years, seem to promote the outbreak of the disease or favour its decline. We may consider the disease as usually pretty much in abeyance until about the 27th week of the year, that is, the first week in July.

—	Average of new Cases.	Mean Temperature.	Mean daily Range.	Mean Humidity.	Mean Rainfall.	Rainy Days, 12 Years.
		°	°		Inches.	
24th week	4·0	58·8	21·8	74	0·35	
25th " -	4·0	60·2	22·0	75	0·47	
26th " -	3·6	60·4	20·7	74	0·48	
27th " -	*6·5*	*59·9*	*21·5*	*74*	*0·40*	
28th " -	6·7	63·6	23·7	73	0·23	
29th " -	7·0	63·5	20·2	73	0·59	
30th " -	6·6	62·0	21·4	73	0·63	
31st " -	5·4	61·1	22·4	71	0·39	
32nd " -	6·7	62·4	21·2	76	0·65	
33rd " -	6·5	62·2	20·0	76	0·40	
34th " -	6·8	60·8	19·3	78	0·74	
35th " -	7·7	59·8	19·9	76	0·38	
36th " -	7·5	60·3	18·9	79	0·48	
37th " -	8·2	58·7	16·3	78	0·50	
38th " -	*10·2*	*56·7*	*16·2*	*79*	*0·40*	
39th " -	11·5	55·5	17·1	84	0·55	
40th " -	12·3	54·5	16·2	83	0·37	
41st " -	*11·5*	*52·5*	15·1	*87*	0·50	
42nd " -	9·9	51·2	14·3	88	0·87	
43rd " -	9·2	48·8	14·1	89	0·54	
44th " -	10·1	46·7	14·8	88	0·47	
45th " -	7·3	43·0	13·1	87	0·30	
46th " -	8·3	41·6	12·7	88	0·49	
47th " -	8·0	41·2	12·4	83	0·44	
48th " -	8·4	42·2	10·3	88	0·44	
49th " -	8·8	42·9	10·9	90	0·46	
50th " -	6·5	41·5	9·2	88	0·35	
51st " -	5·9	40·8	10·4	86	0·28	
52nd " -	4·4	39·6	9·7	87	0·31	



Respiratory Diseases

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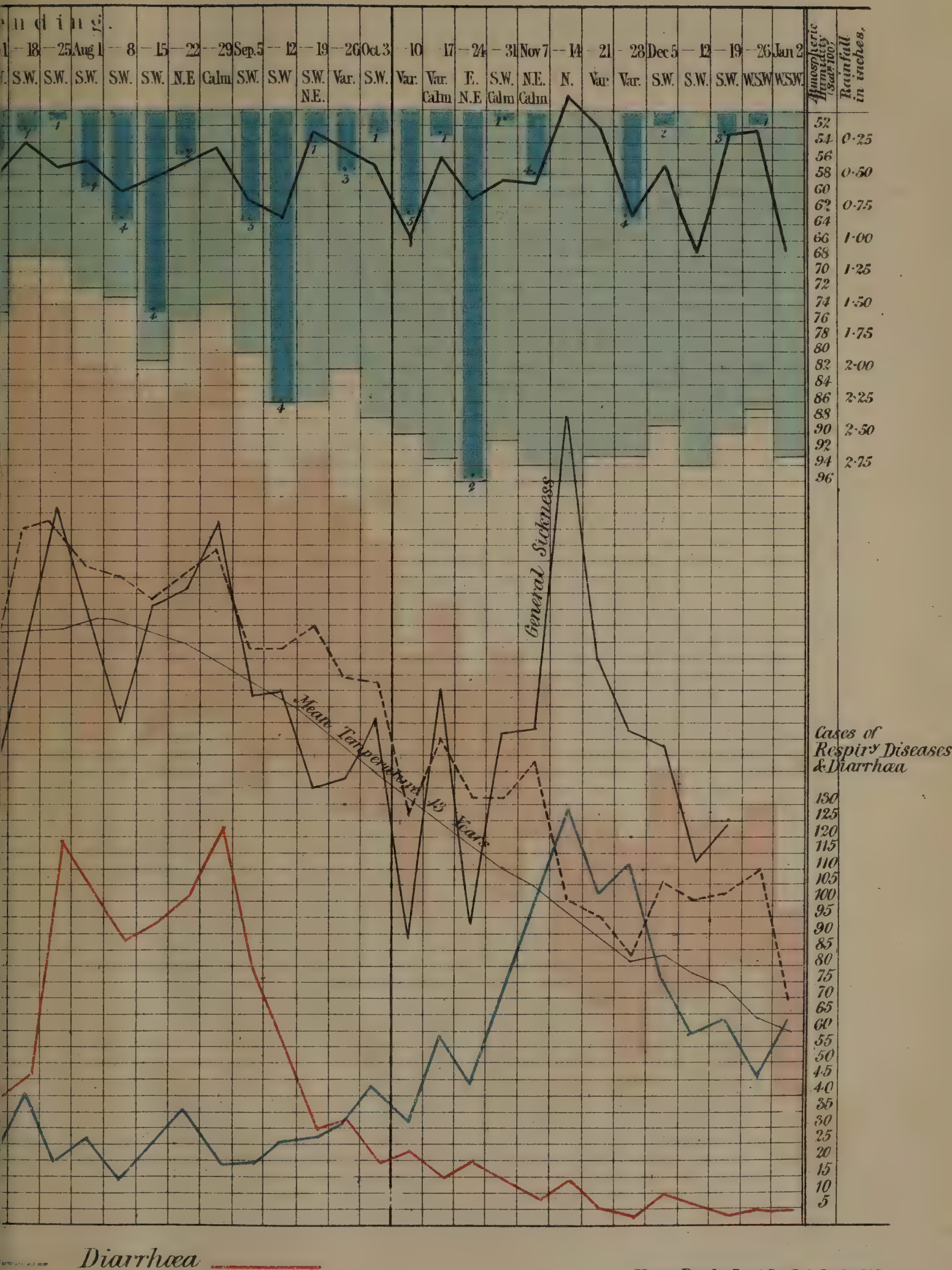
No. 1.



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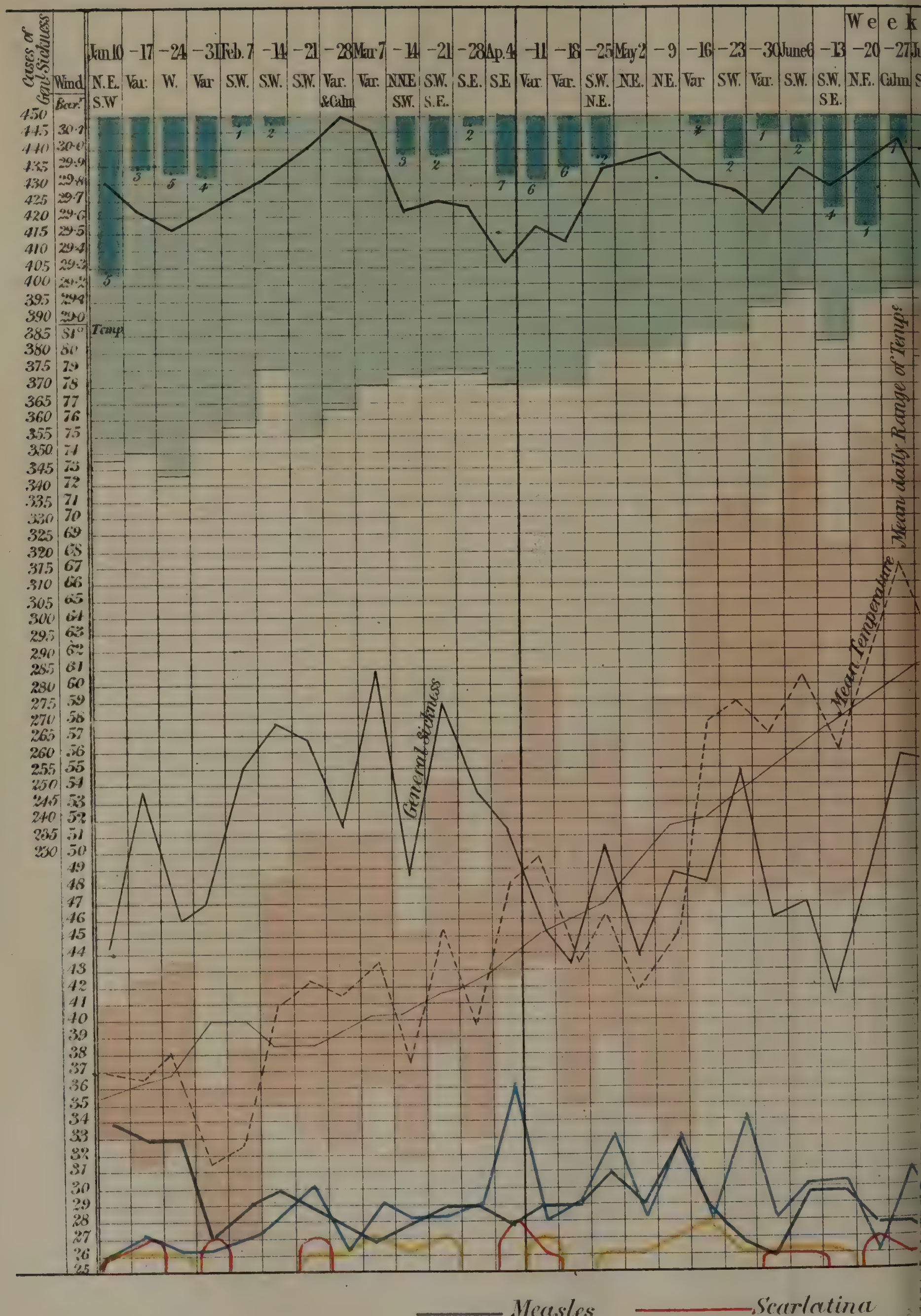

Week
Cases of Genl. Sickness
Wind
Bar.
Temp.
Jan 10 -17 -24 -31 Feb. 7 -14 -21 -28 Mar 7 -14 -21 -28 Ap. 4 -11 -18 -25 May 2 -9 -16 -23 -30 June 6 -13 -20 -27
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S.W.
Var.
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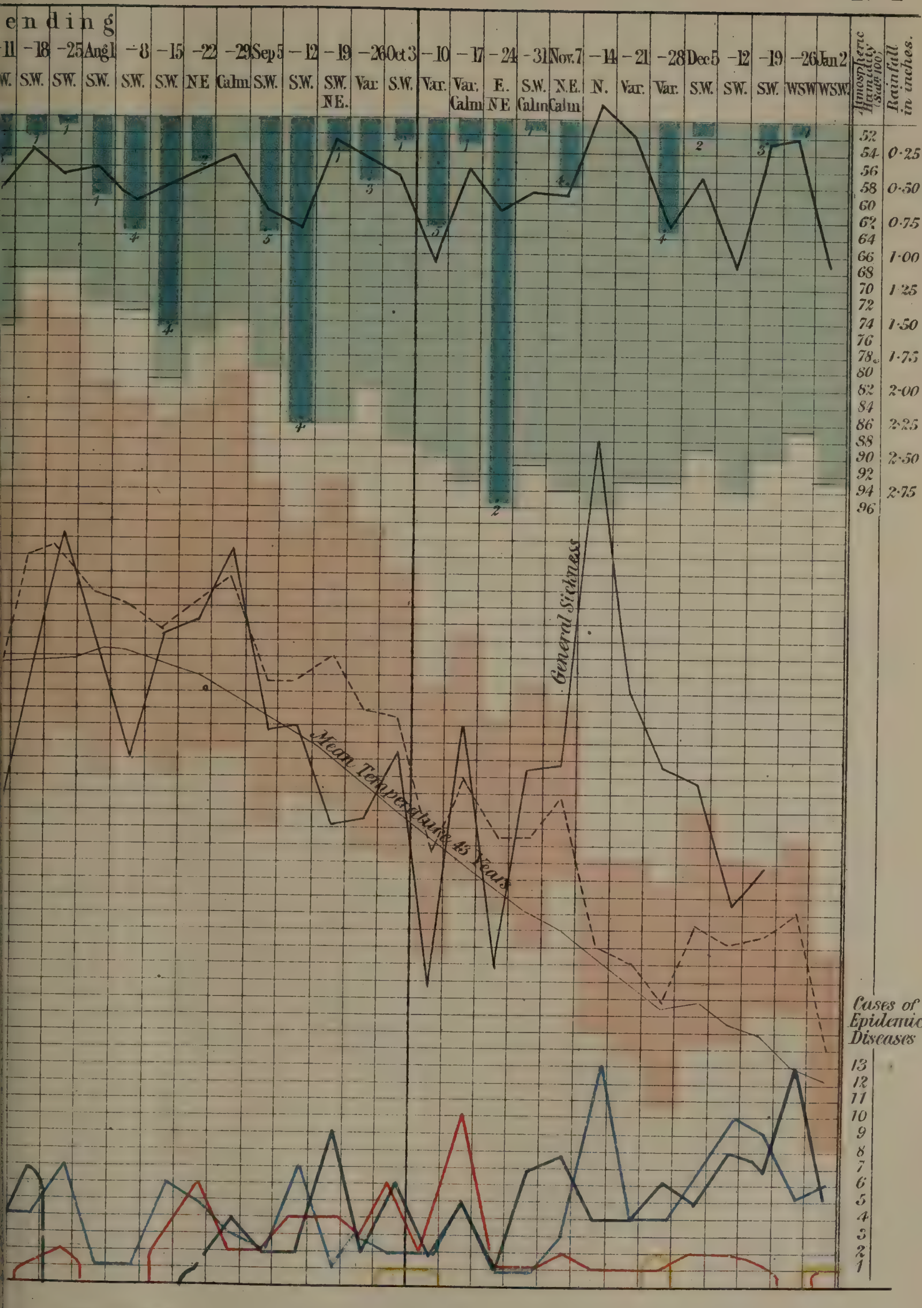
Calm
General Sickness
Mean Temperature
Mean daily Range of Temp.
Measles
Scarlatina

7.

Nº 2



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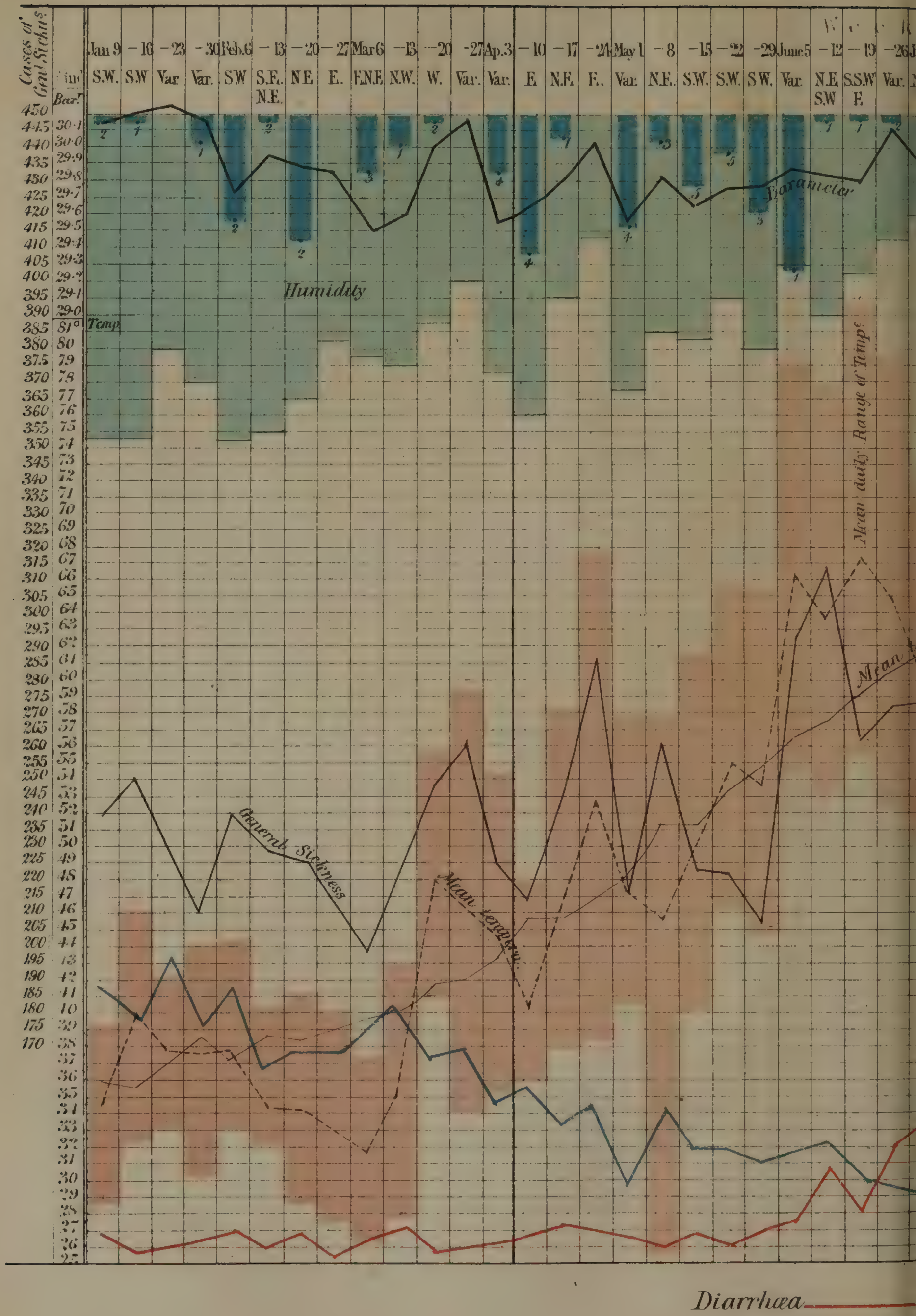
Cases of Gen! Sickness
Wind
Bar.
Temp.
Jan 9
S.W.
Feb.6
Mar 6
Ap.3
May 1
June 5
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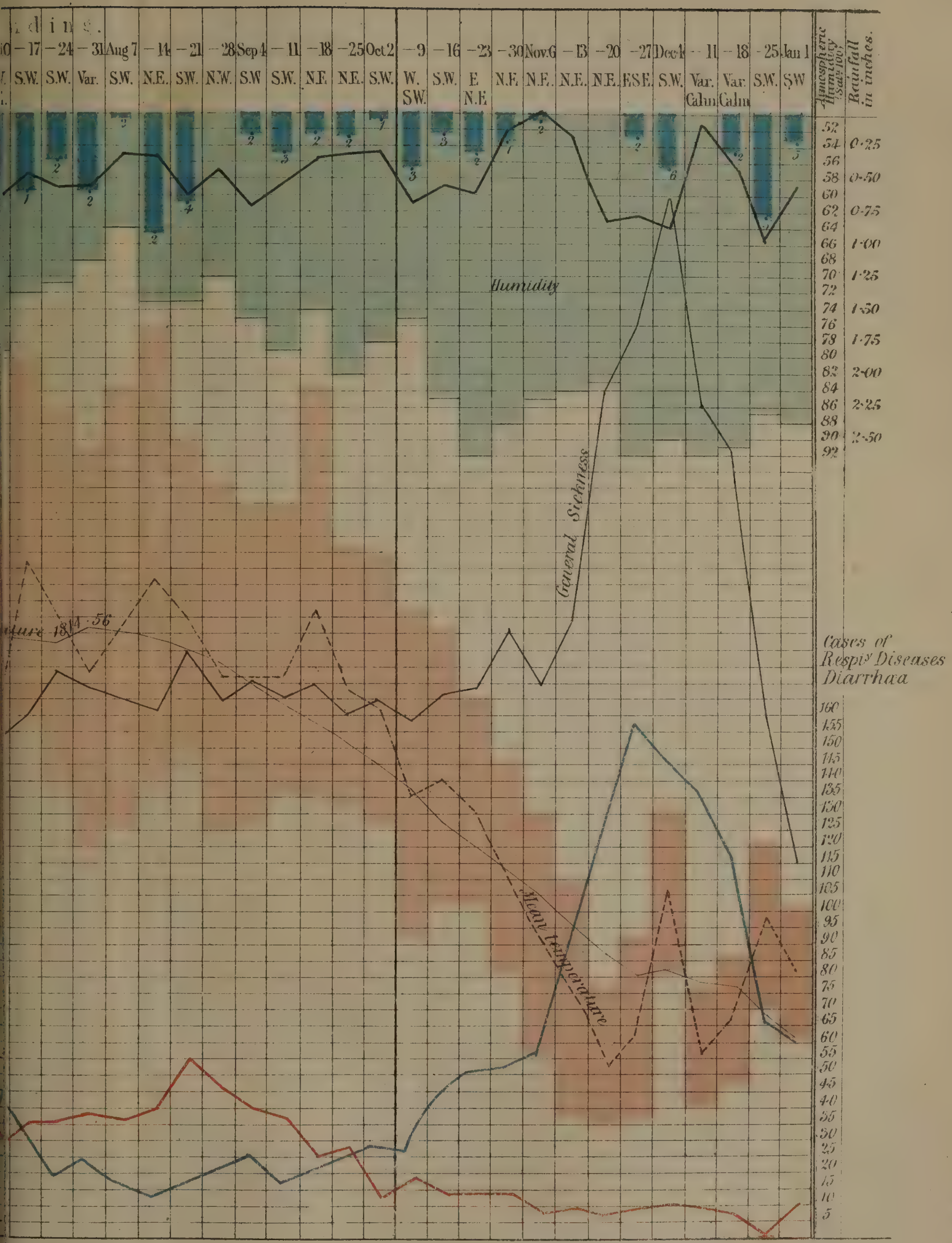
General Sickness
Mean tempre
Mean daily Range of Temp.
Mean
Diarrhœa

3.

N° 3.



Respiratory Diseases ———

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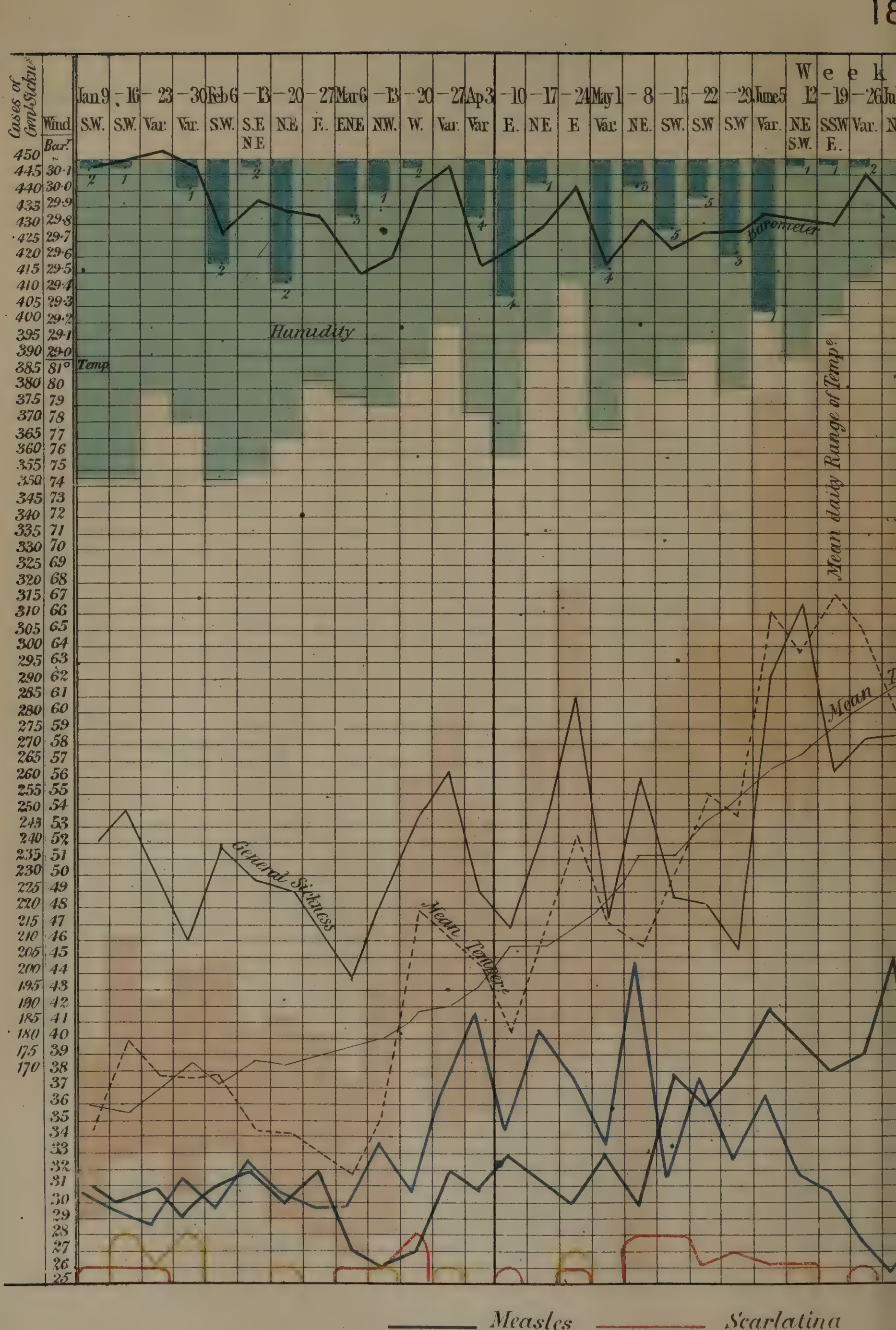
18
Week
Cases of Genl Sickness
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Bar.
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Jan 9
- 16
- 23
- 30
Feb 6
- 13
- 20
- 27
Mar 6
- 13
- 20
- 27
Ap 3
- 10
- 17
- 24
May 1
- 8
- 15
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June 5
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S.W.
S.W.
Var.
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S.W.
S.E. N.E.
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S.S.W. E.
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Mean
Measles
Scarlatina

8.

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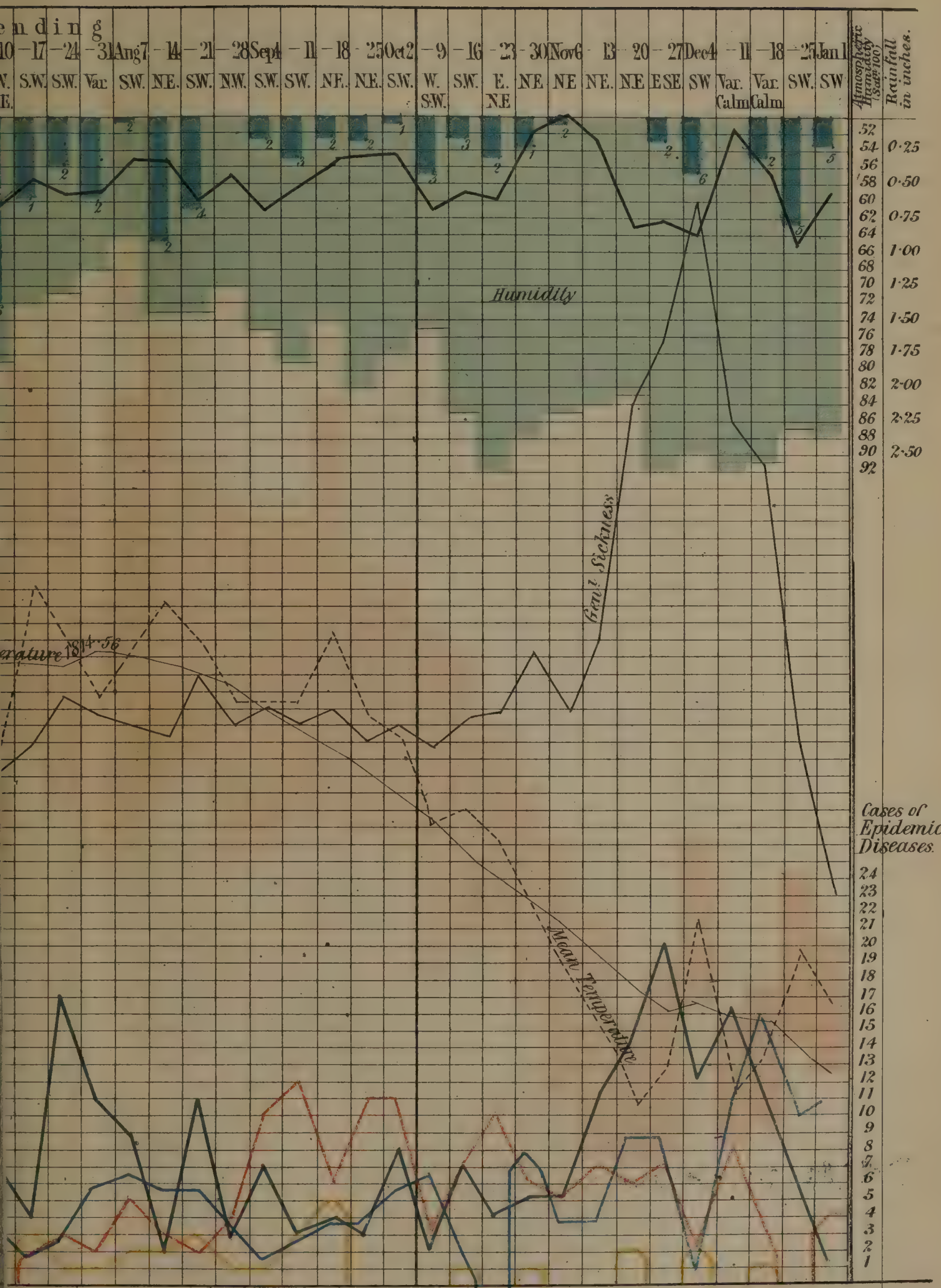

Small pox Hooping Cough

Vincent Brooks Day & Son, Lith. London W.C.

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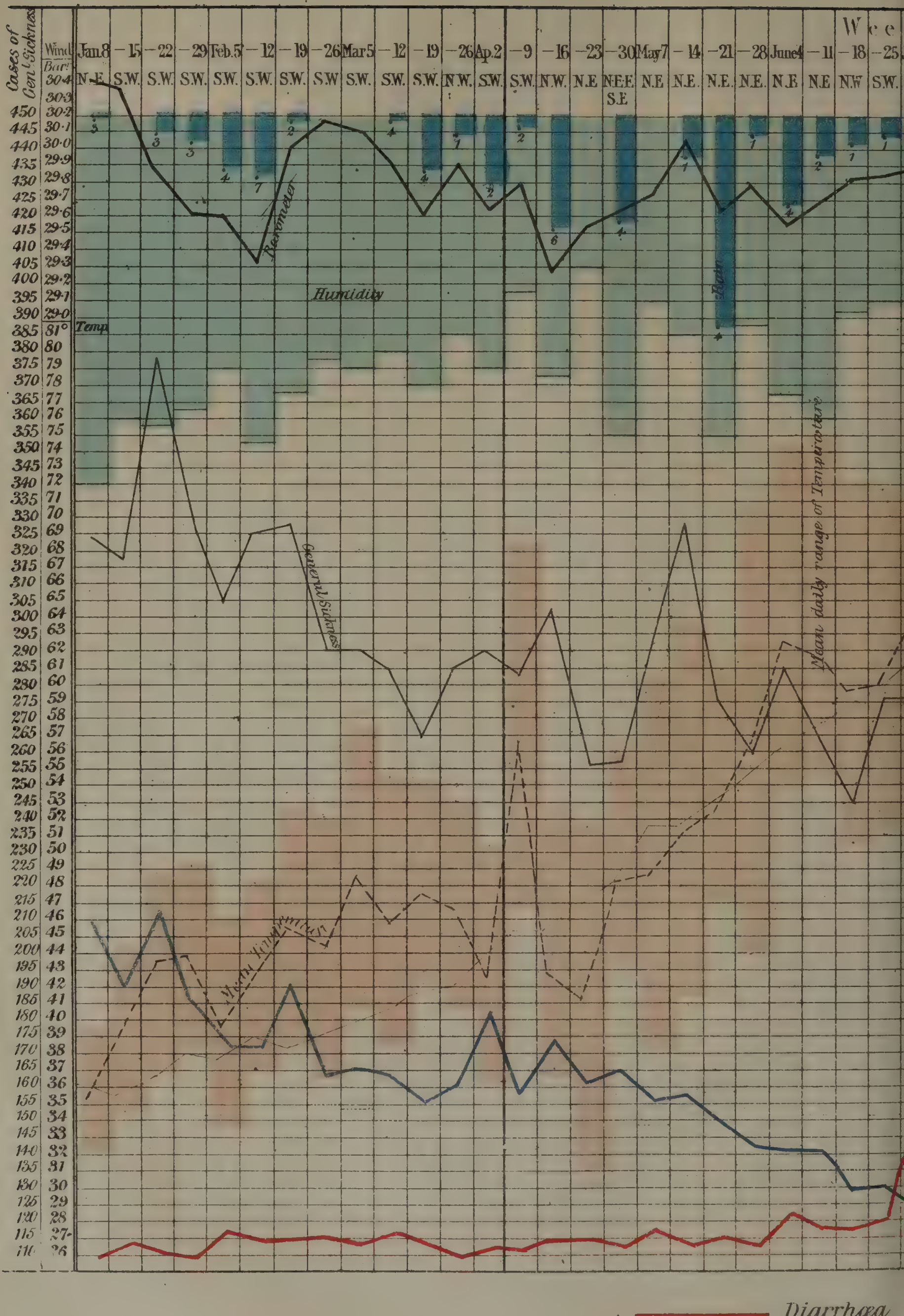

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Cases of Genl. Sickness
Wind
Bar.
Temp
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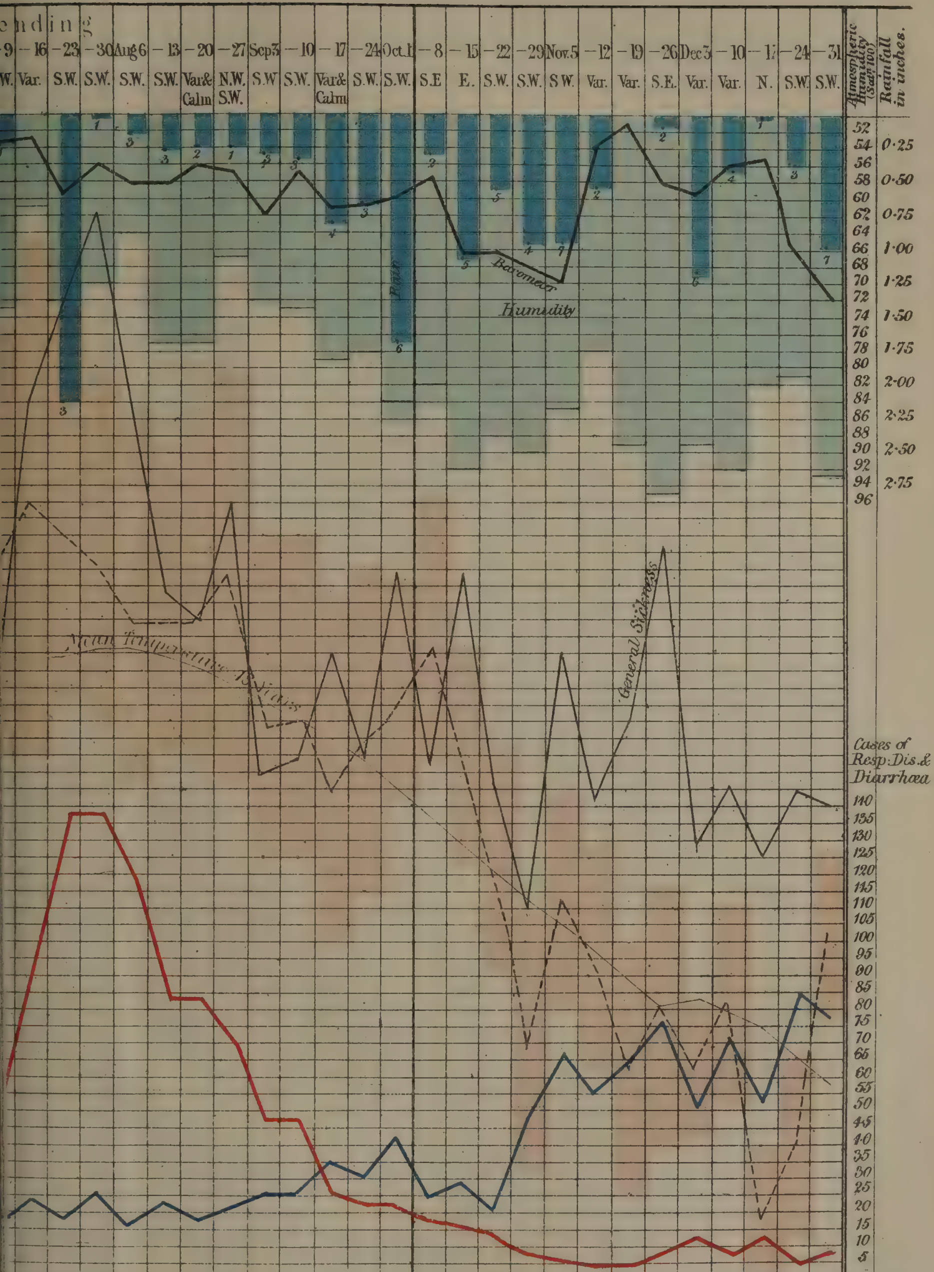
N.E. S.W. S.W. S.W. S.W. S.W. S.W. S.W. S.W. S.W. S.W. N.W. S.W. S.W. N.W. N.E. N.E.E. S.E. N.E. N.E. N.E. N.E. N.E. N.E. N.W. S.W.
Barometer
Humidity
Rain
General Sickness
Mean daily range of Temperature
Mean Temp.
Diarrhœa

9.

Nº 5.



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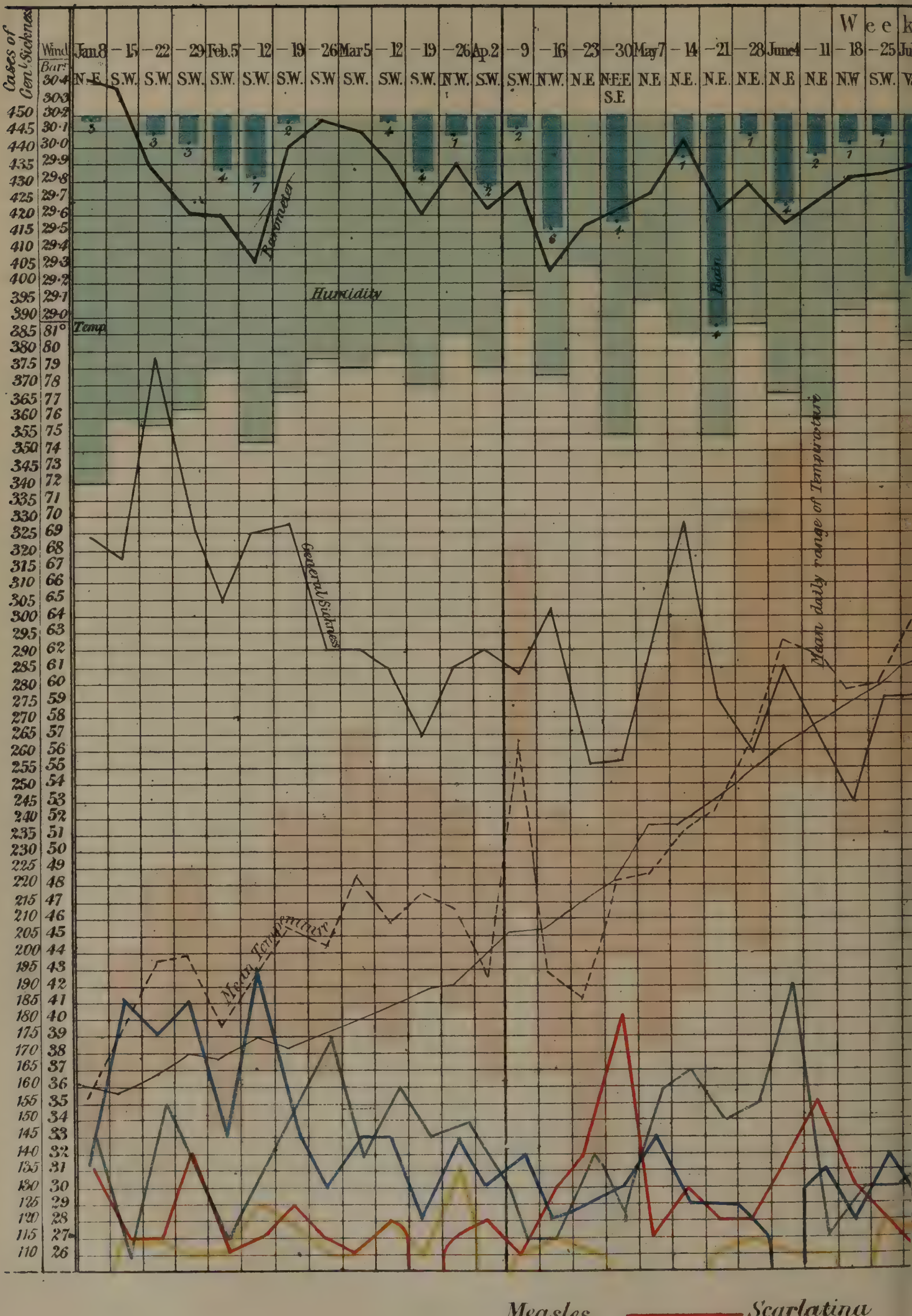
Cases of Gen.l Sickness
Wind
Bar.
Week
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N.E. S.W. S.W. S.W. S.W. S.W. S.W. S.W. S.W. S.W. S.W. N.W. S.W. S.W. N.W. N.E. N.E.E. S.E. N.E. N.E. N.E. N.E. N.E. N.E. N.W. S.W.
Barometer
Humidity
Rain
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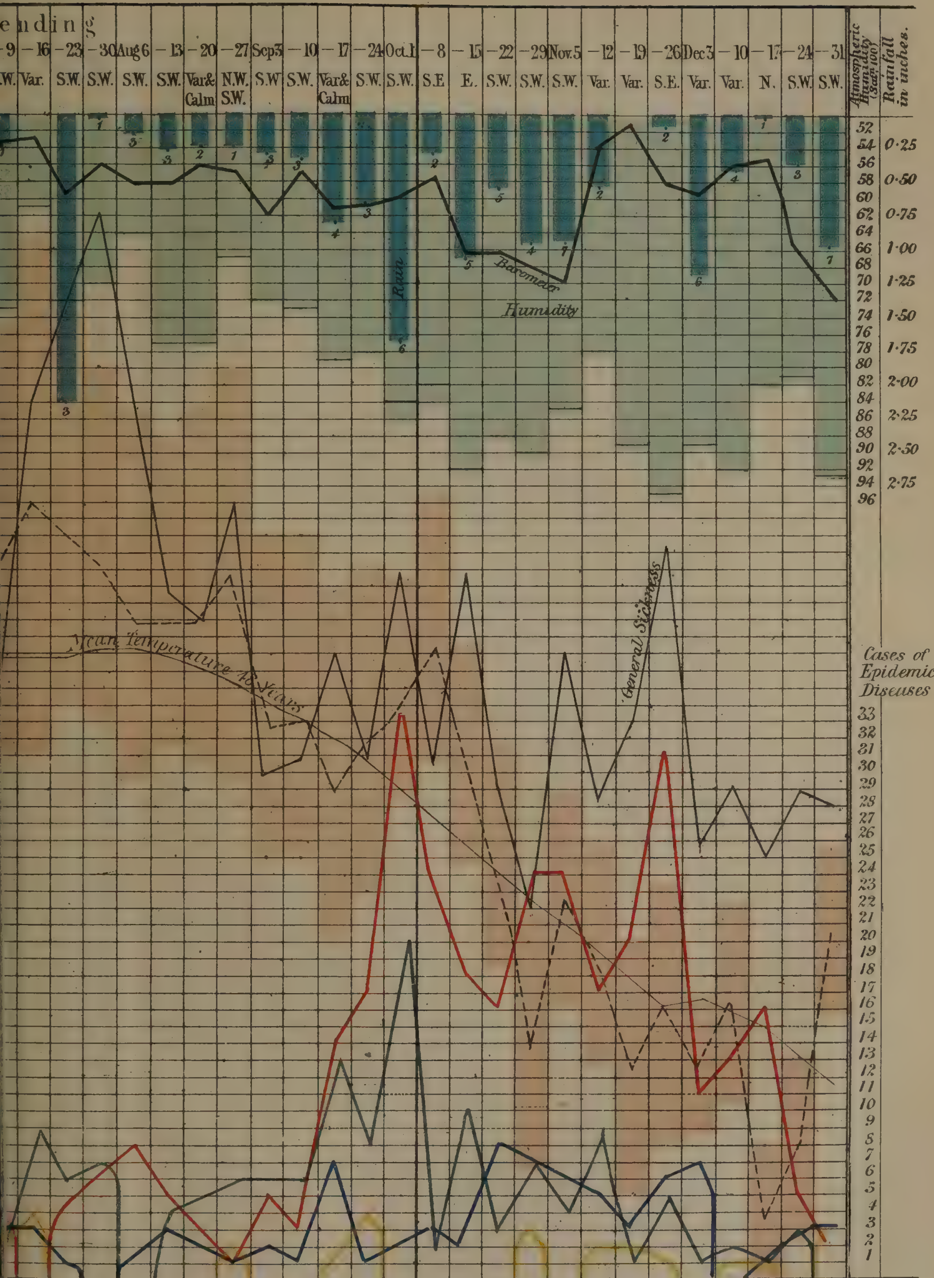
General Sickness
Mean daily range of Temperature
Mean Temperature
Measles
Scarlatina

9.



Small pox — Hooping Cough

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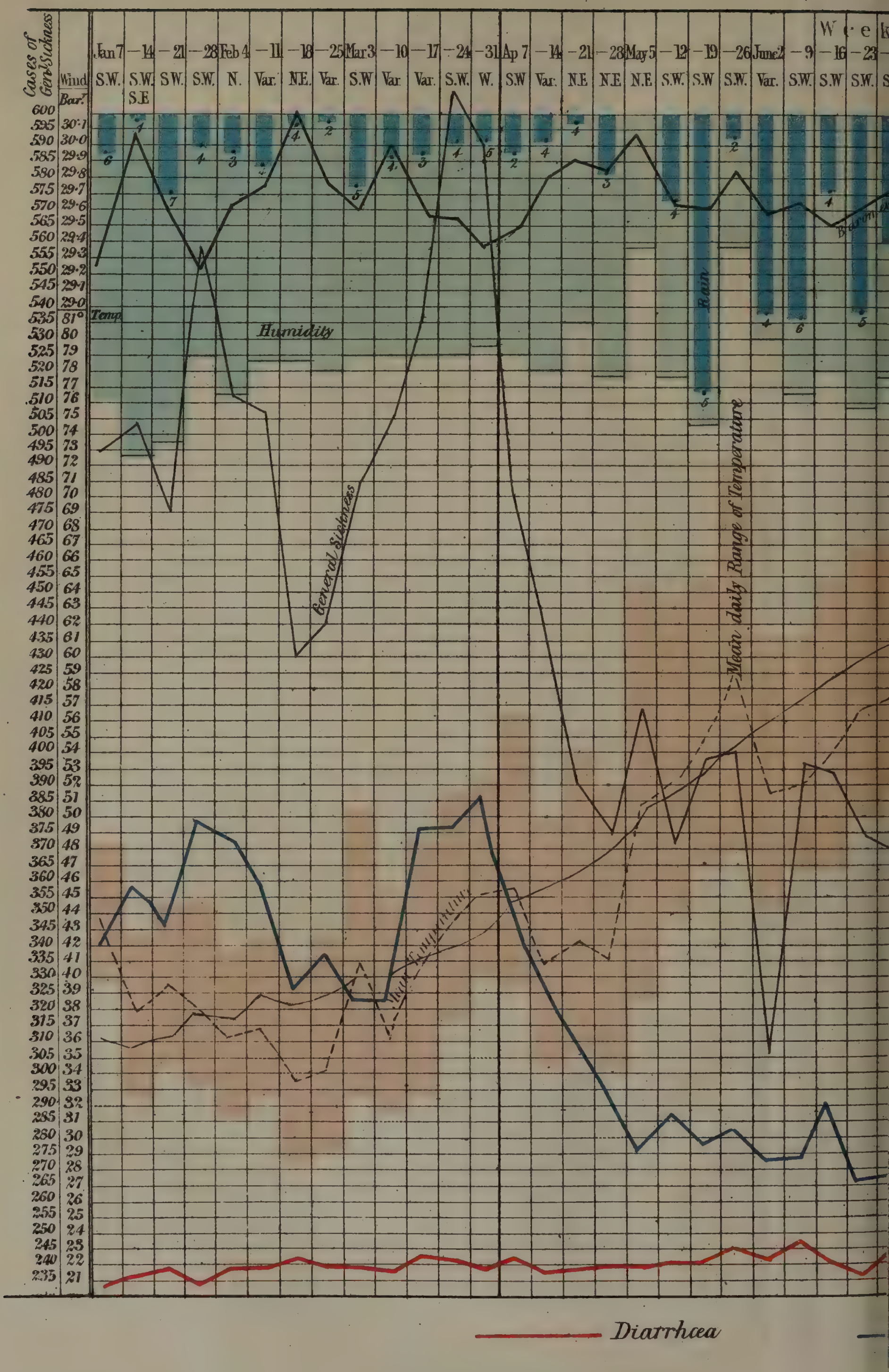

Cases of Genl Sickness
Wind
Bar.
Temp
Jan 7
Feb 4
Mar 3
Ap 7
May 5
June 2
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S.E
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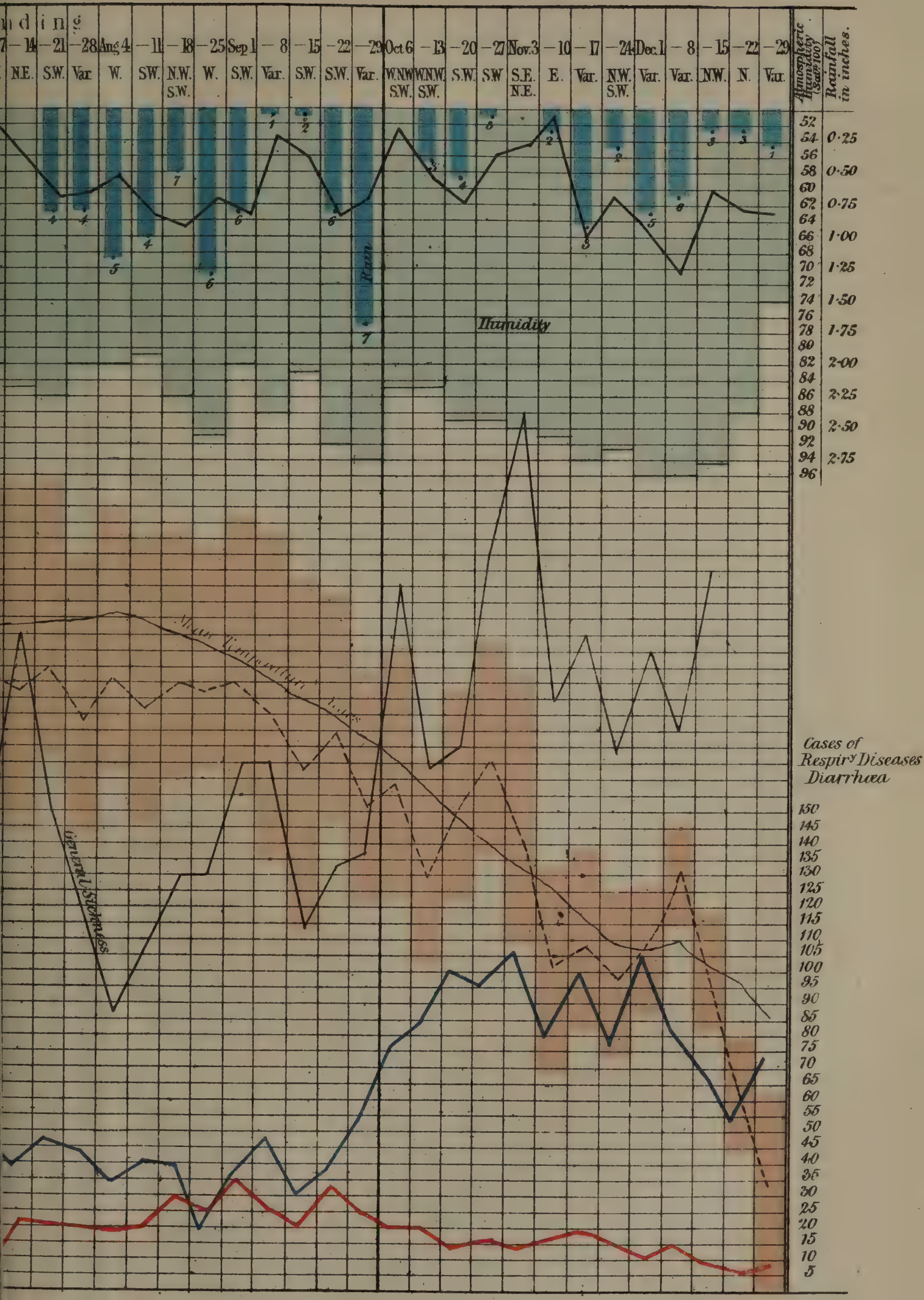
Humidity
General Sickness
Rain
Mean daily Range of Temperature
Diarrhœa

O.

No. 7.



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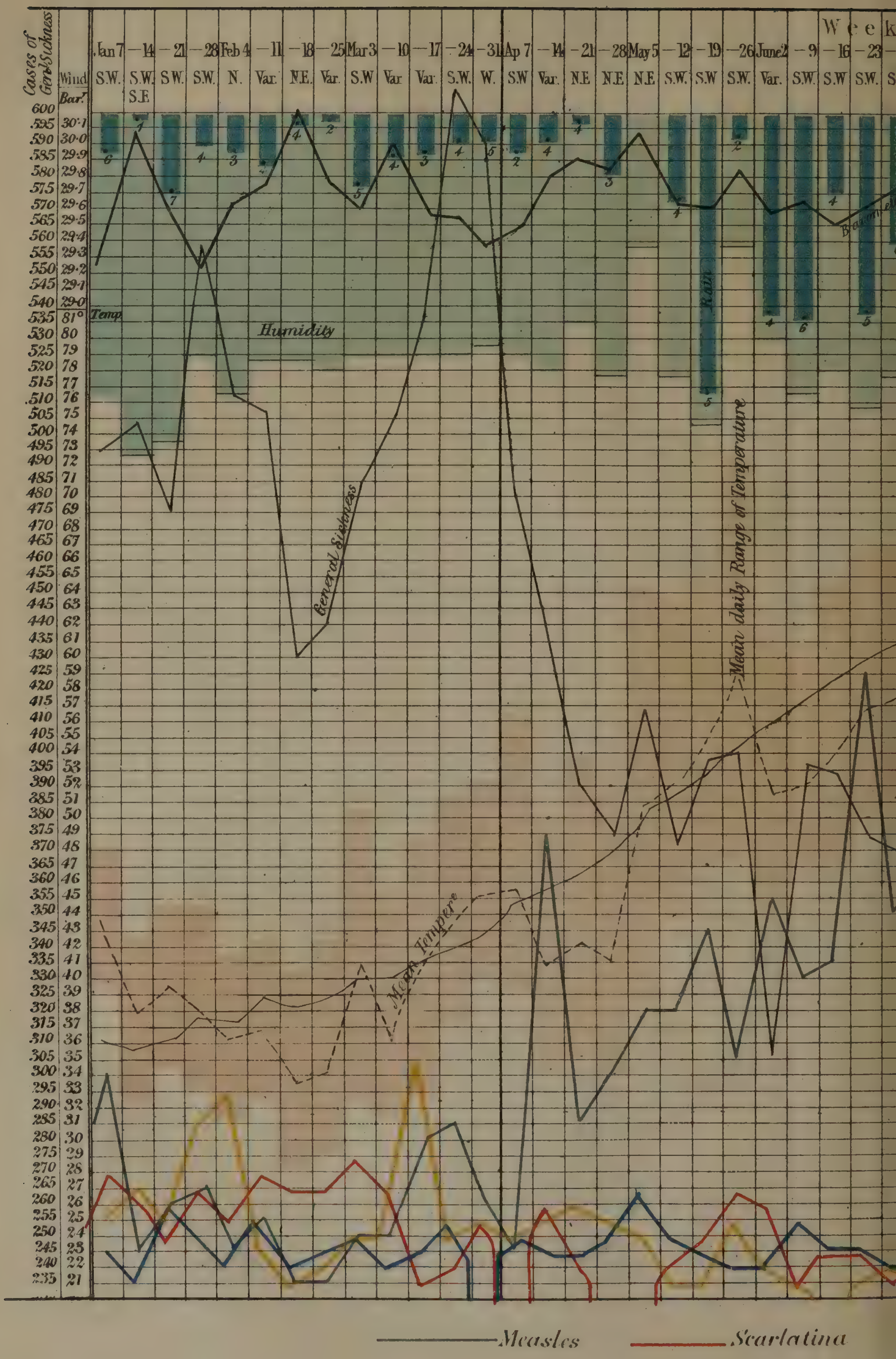
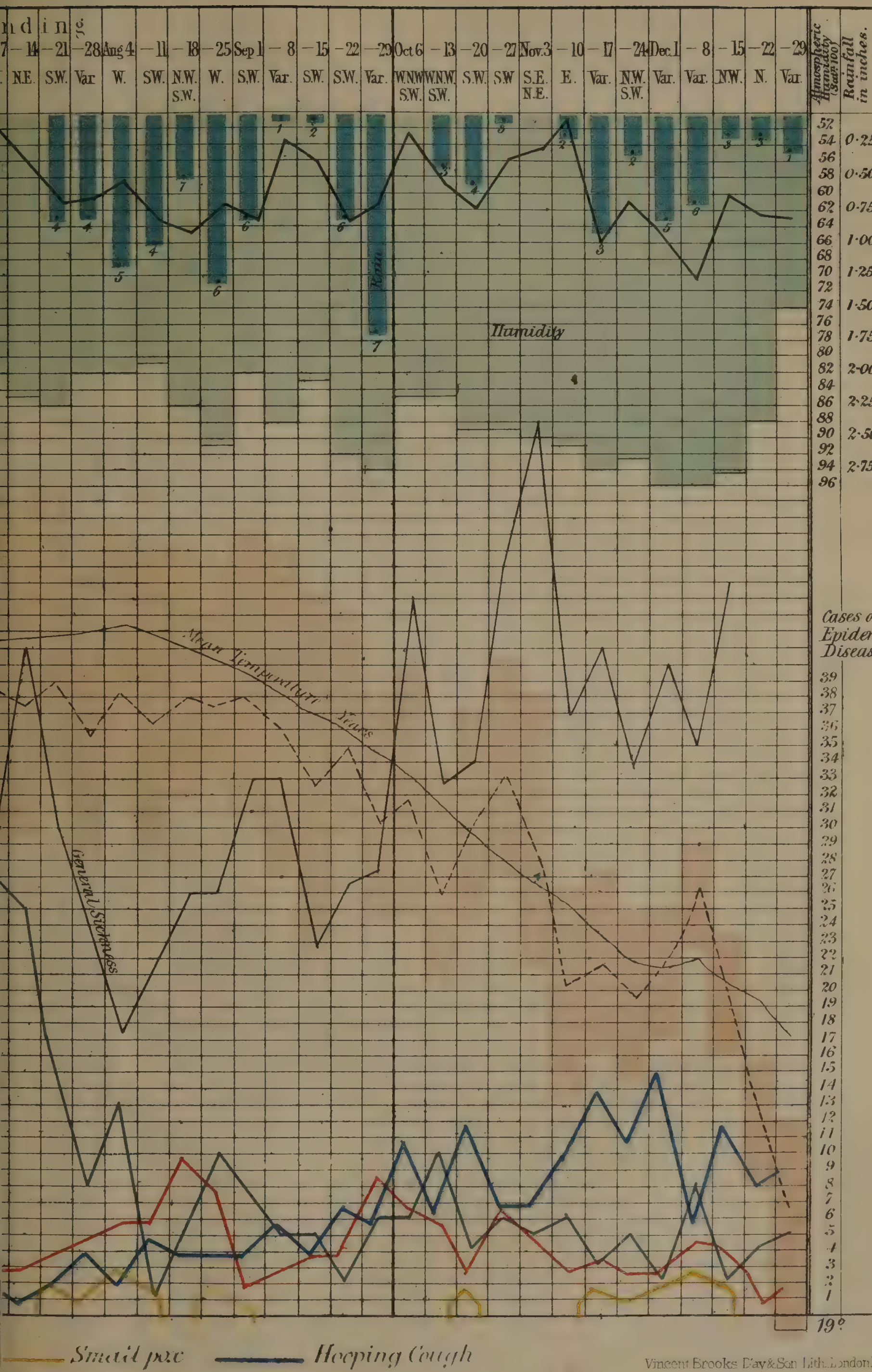


Cases of Genl. Sickness
Wind
Bar.
Temp.
Week
Jan 7 — 14 — 21 — 28 Feb 4 — 11 — 18 — 25 Mar 3 — 10 — 17 — 24 — 31 Ap 7 — 14 — 21 — 28 May 5 — 12 — 19 — 26 June 2 — 9 — 16 — 23
S.W. S.W. S.E. S.W. S.W. N. Var. N.E. Var. S.W. Var. Var. S.W. W. S.W. Var. N.E. N.E. N.E. S.W. S.W. S.W. Var. S.W. S.W. S.W.
Humidity
Rain
Barometer
General Sickness
Mean daily Range of Temperature
Mean Temperature
Measles
Scarlatina



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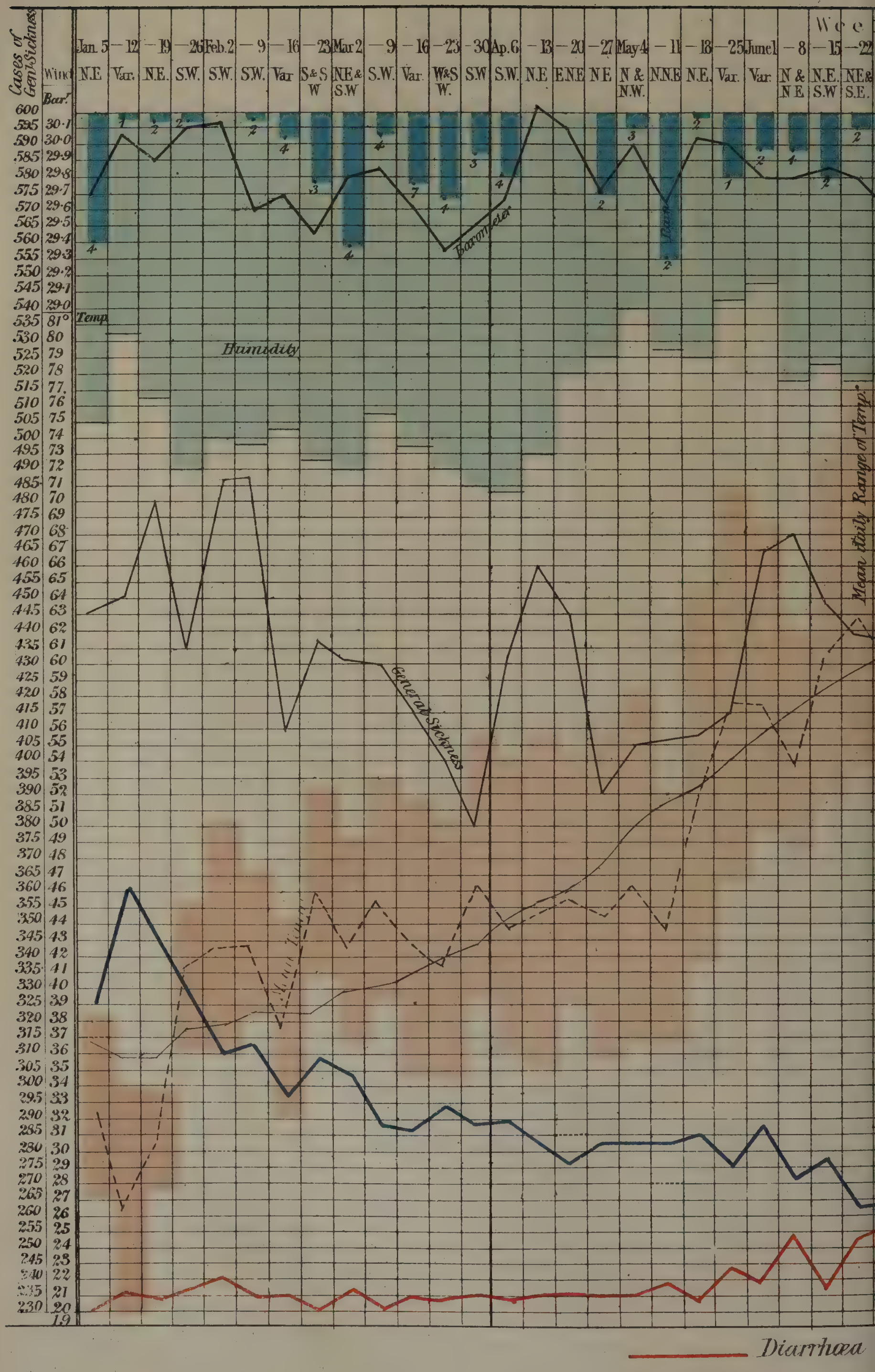

Cases of Genl. Sickness
Wind
Bar.
Jan. 5
— 12
— 19
— 26
Feb. 2
— 9
— 16
— 23
Mar 2
— 9
— 16
— 23
— 30
Ap. 6
— 13
— 20
— 27
May 4
— 11
— 18
— 25
June 1
— 8
— 15
— 22
N.E.
Var.
N.E.
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Var.
S.&S W
NE & S.W
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Var.
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Var.
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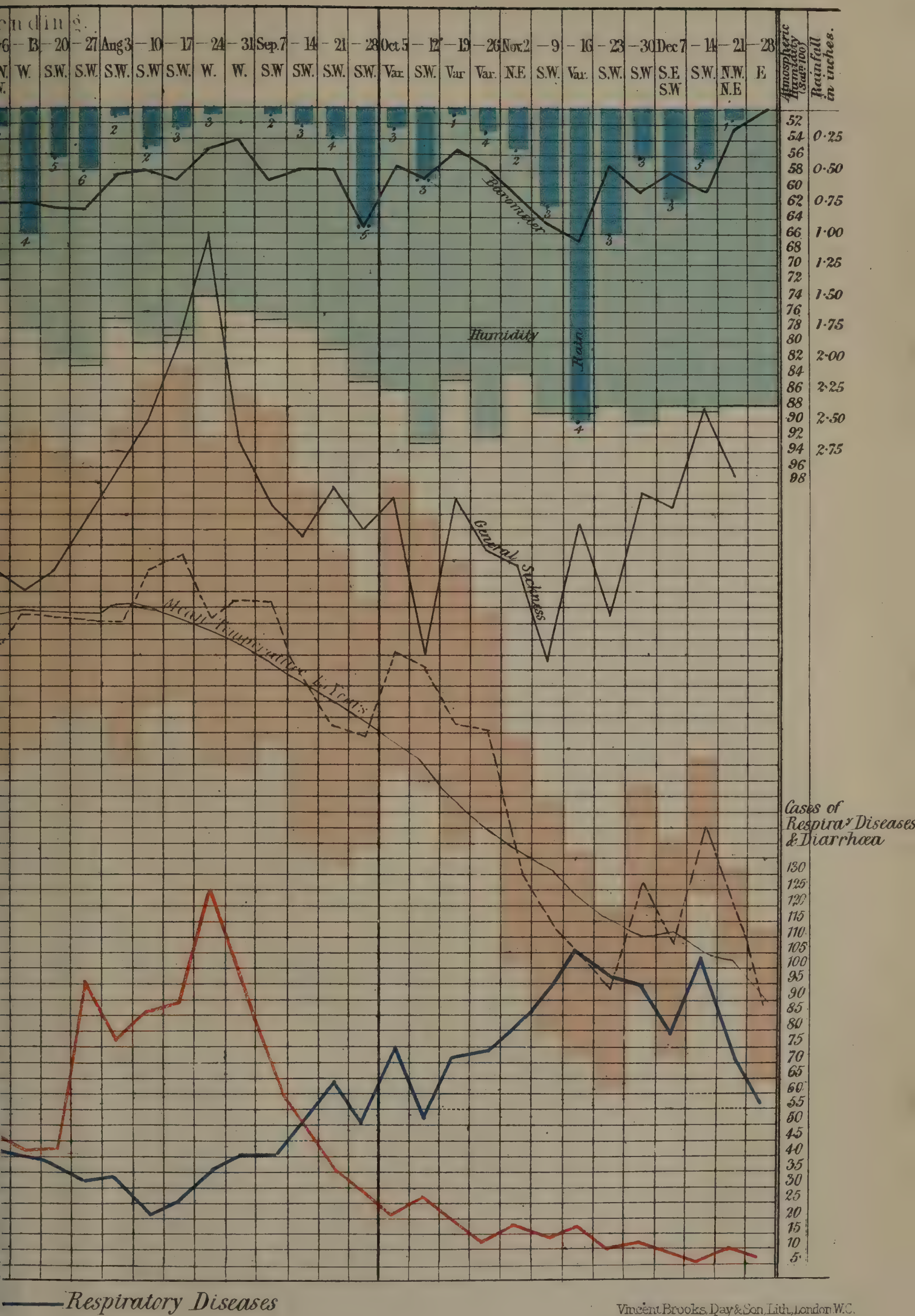
NE & S.E.
Temp.
Humidity
Barometer
Rain
General Sickness
Mean daily Range of Temp.
Diarrhœa



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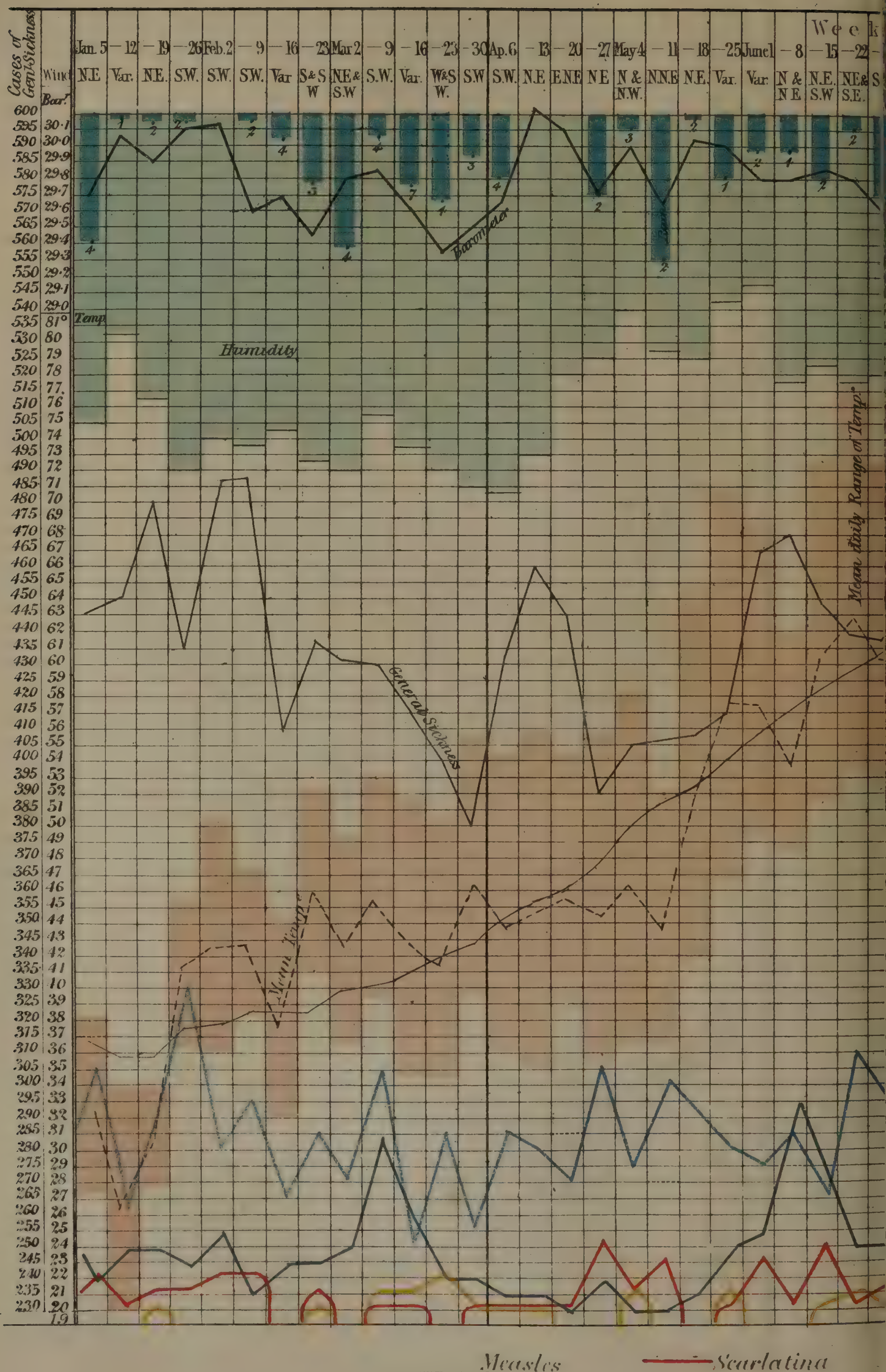
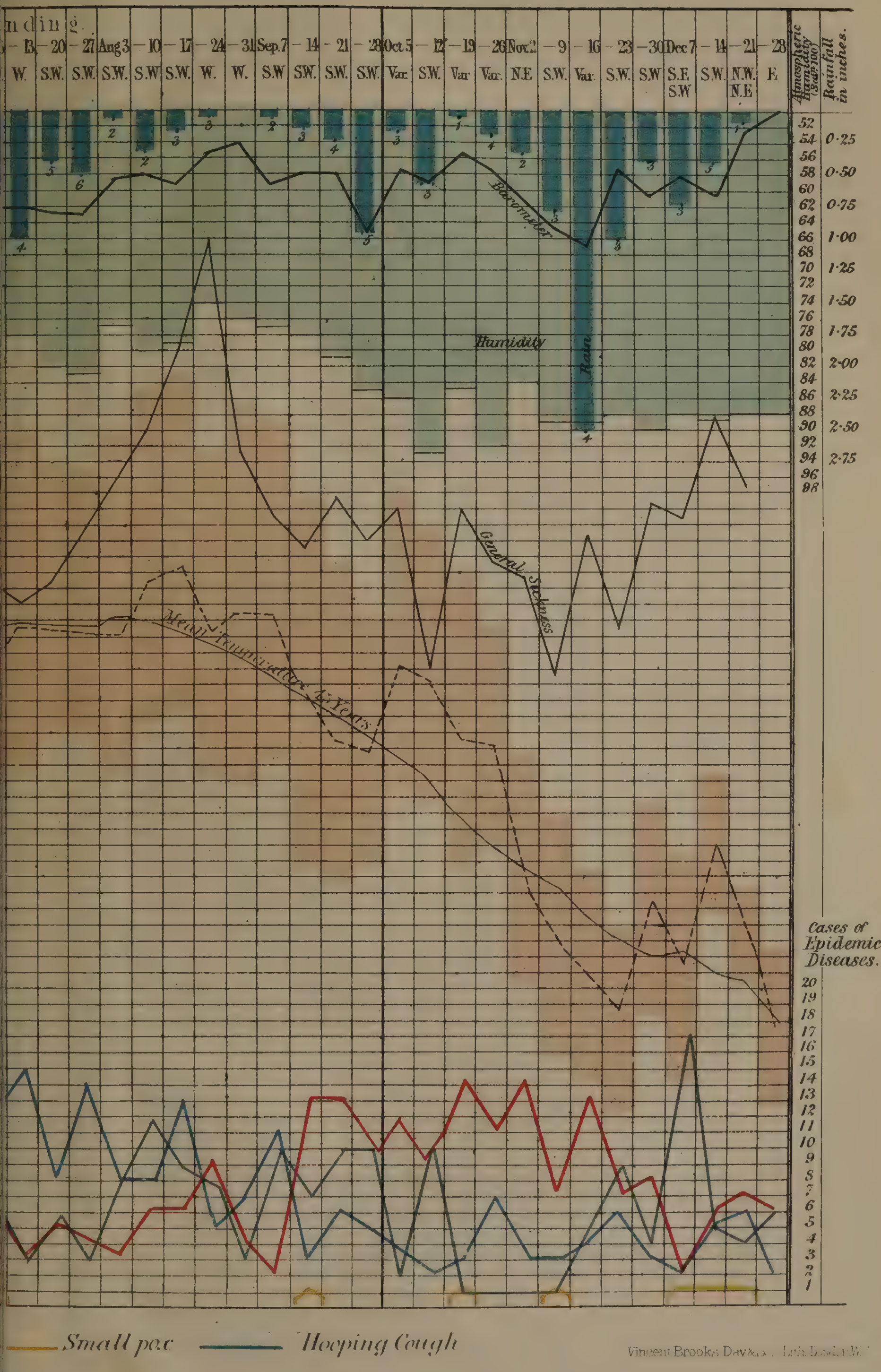

Week
Cases of Genl. Sickness
Wind
Bar.
Jan. 5 — 12 — 19 — 26 Feb. 2 — 9 — 16 — 23 Mar 2 — 9 — 16 — 23 — 30 Ap. 6 — 13 — 20 — 27 May 4 — 11 — 18 — 25 June 1 — 8 — 15 — 22
N.E. Var. N.E. S.W. S.W. S.W. Var S & S W NE & S.W S.W. Var. W & S W. S.W S.W. N.E E.N.E N.E N & N.W. N.N.E N.E. Var. Var. N & N.E. N.E. S.W NE & S.E.
Temp.
Humidity
Barometer
General Sickness
Mean Temp.
Mean daily Range of Temp.
Measles
Scarlatina

Nº 10.



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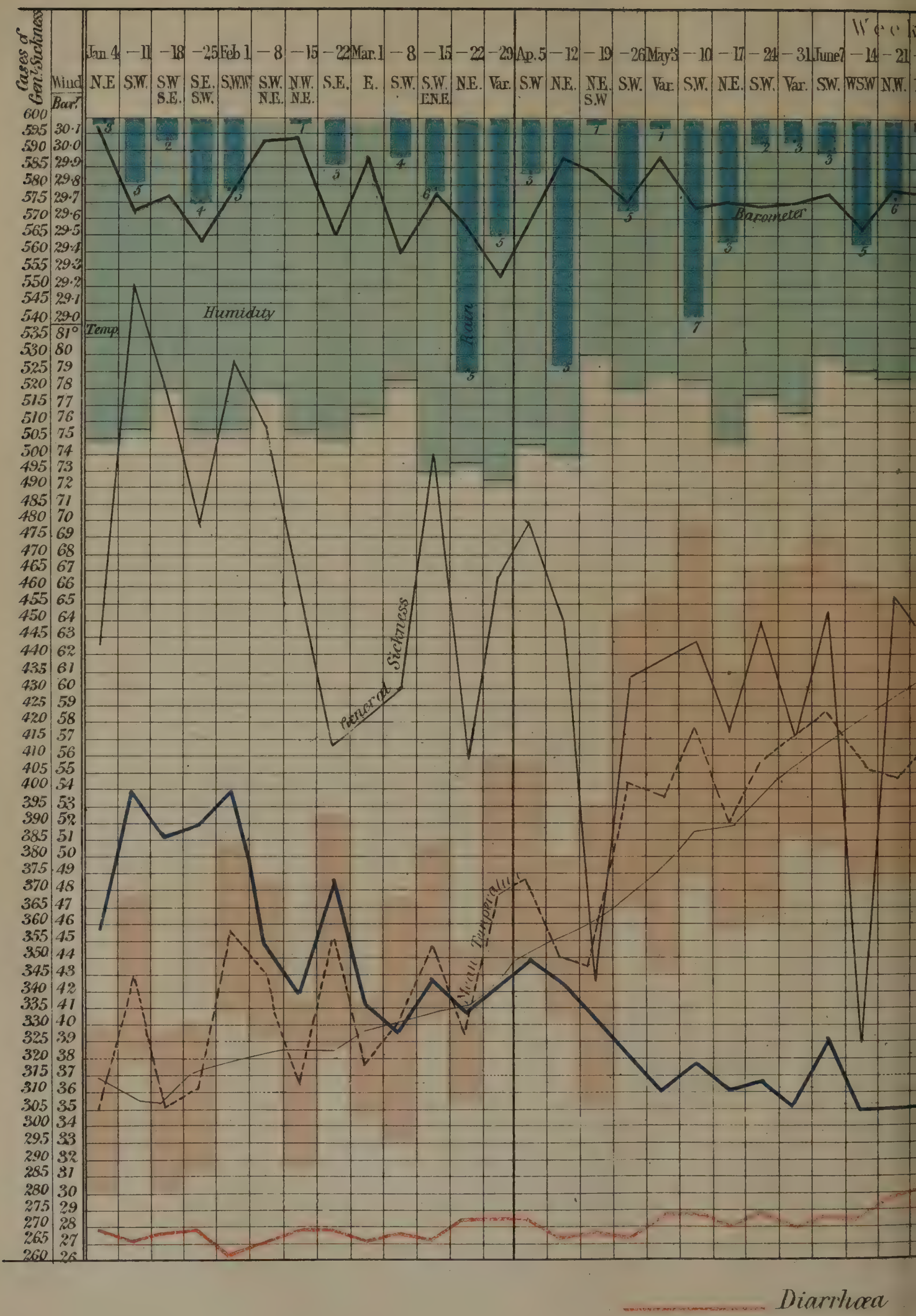
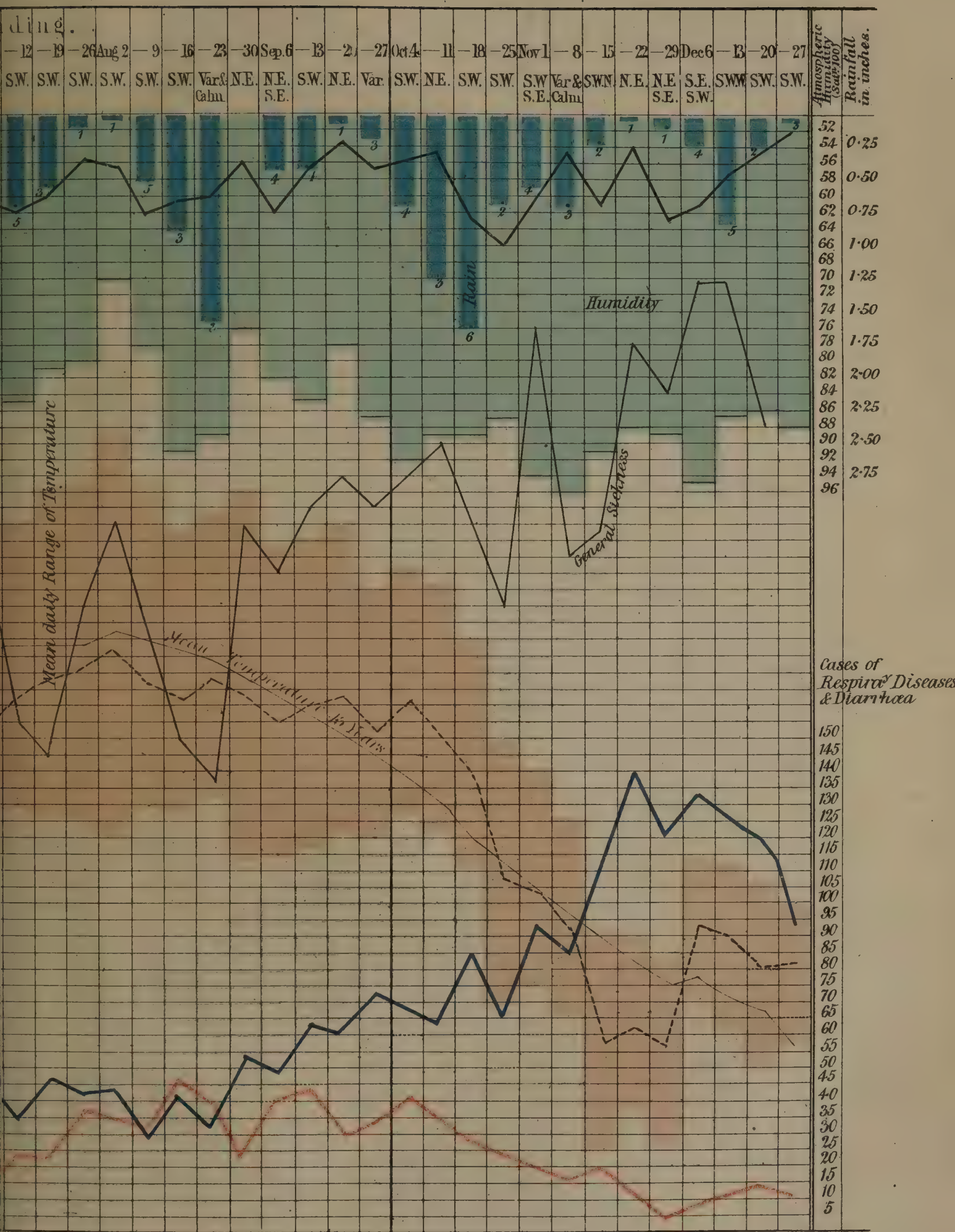

Week
Cases of Genl. Sickness
Wind
Bar.
Temp.
Jan 4 – 11 – 18 – 25 Feb 1 – 8 – 15 – 22 Mar. 1 – 8 – 15 – 22 – 29 Ap. 5 – 12 – 19 – 26 May 3 – 10 – 17 – 24 – 31 June 7 – 14 – 21
N.E. S.W. S.W. S.E. S.E. S.W. S.W.W. S.W. N.E. N.W. N.E. S.E. E. S.W. S.W. E.N.E. N.E. Var. S.W. N.E. N.E. S.W. S.W. Var. S.W. N.E. S.W. Var. S.W. W.S.W. N.W.
Humidity
Barometer
Rain
General Sickness
Mean Temperature
Diarrhœa

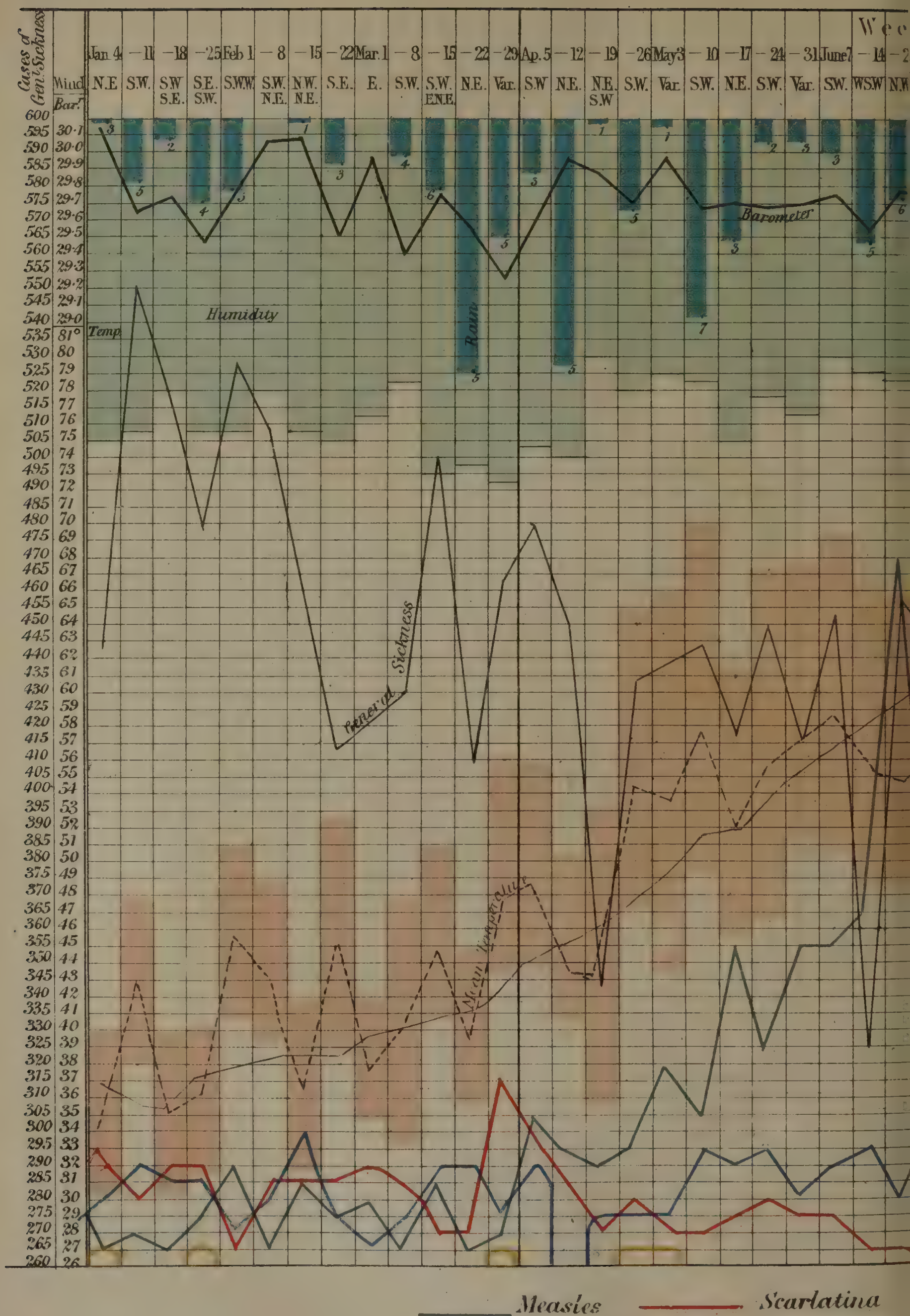
2.

No. 11.



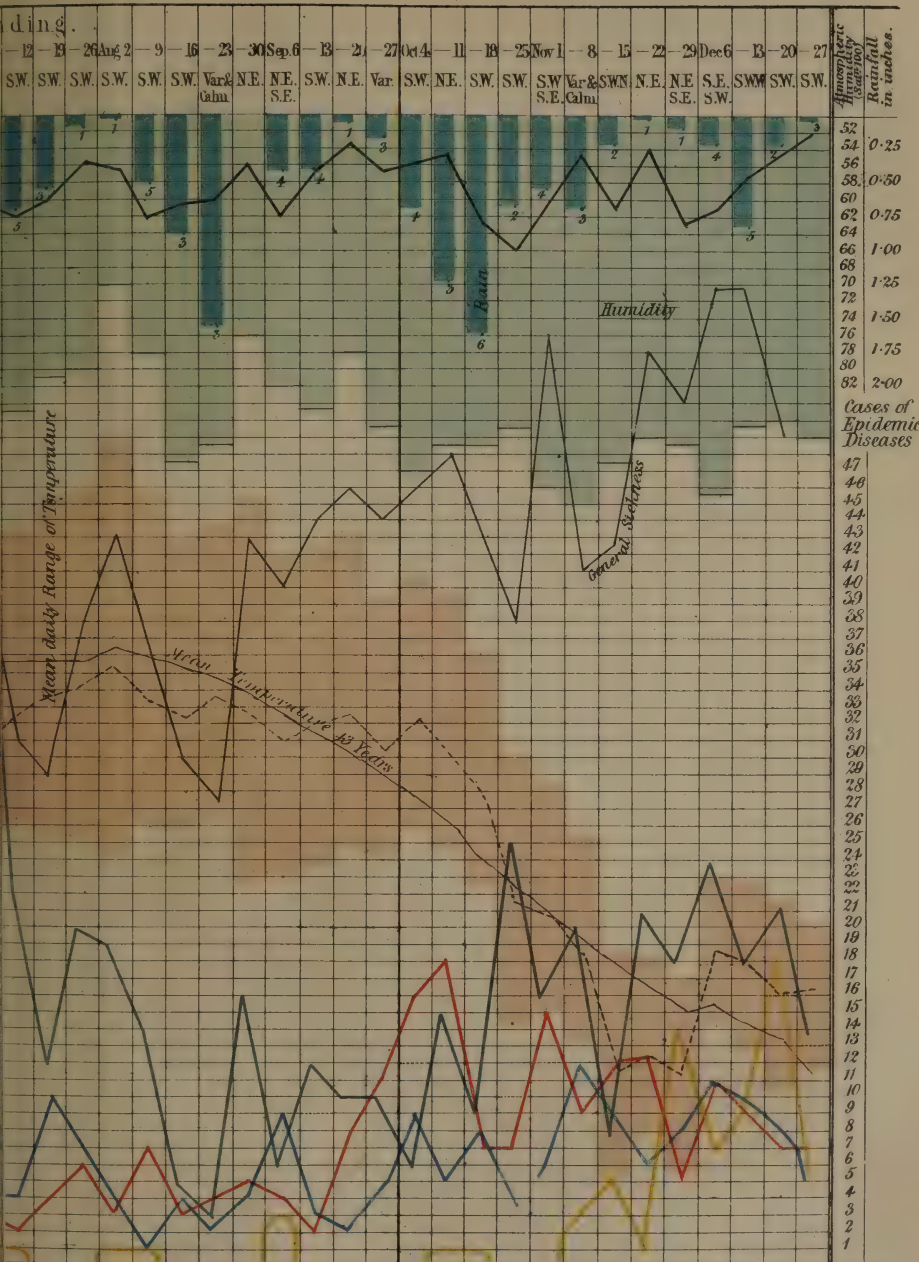
——— Respiratory Diseases

Vincent Brooks, Day & Son, Lith., London W.C.



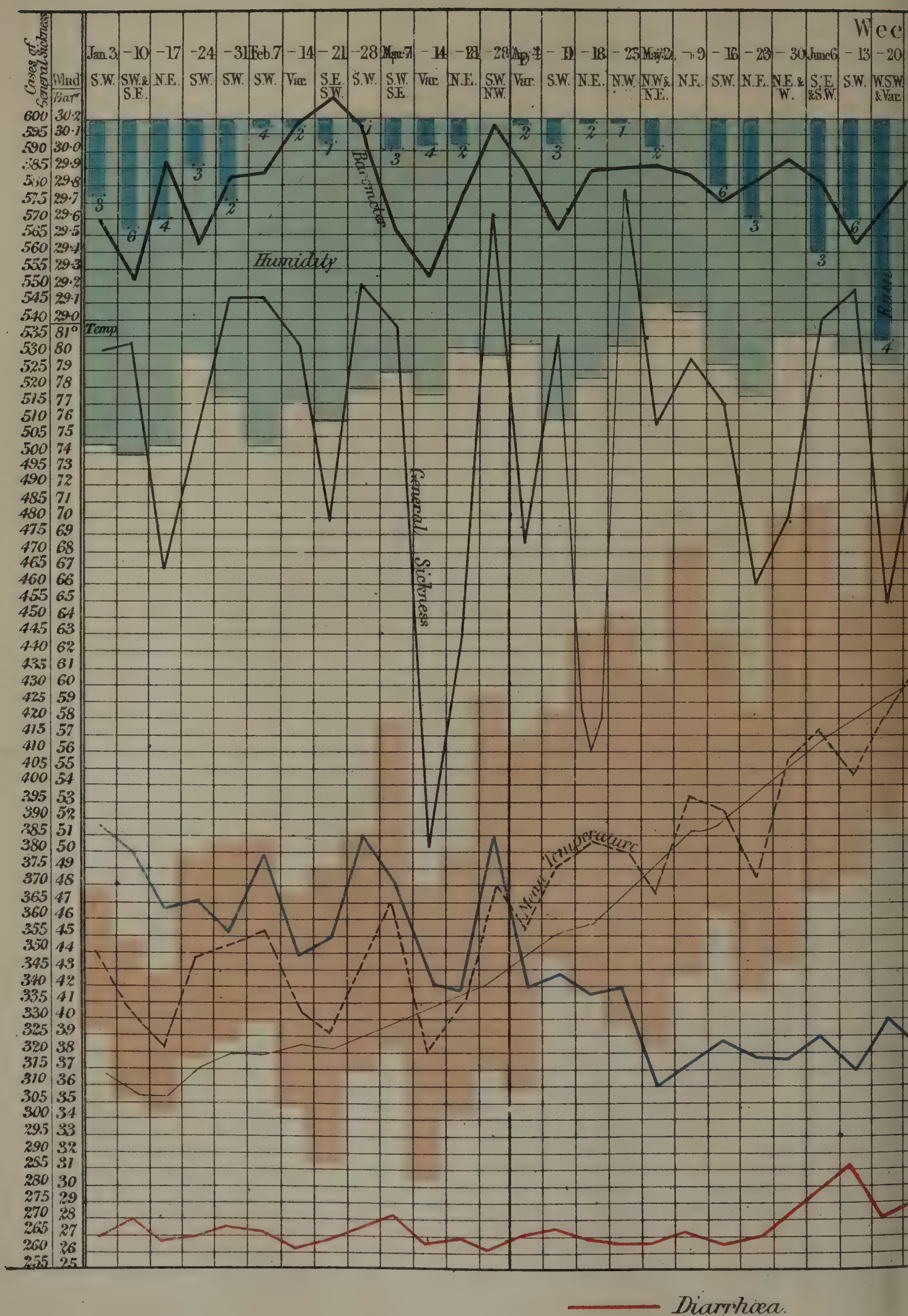
Cases of Gen'l Sickness
Wind
Bar.r
Jan 4 – 11 – 18 – 25 Feb 1 – 8 – 15 – 22 Mar. 1 – 8 – 15 – 22 – 29 Ap. 5 – 12 – 19 – 26 May 3 – 10 – 17 – 24 – 31 June 7 – 14
Temp.
Humidity
Rain
Barometer
General Sickness
Mean Temperature
Measles
Scarlatina

2.



Smallpox. *Hooping Cough.*

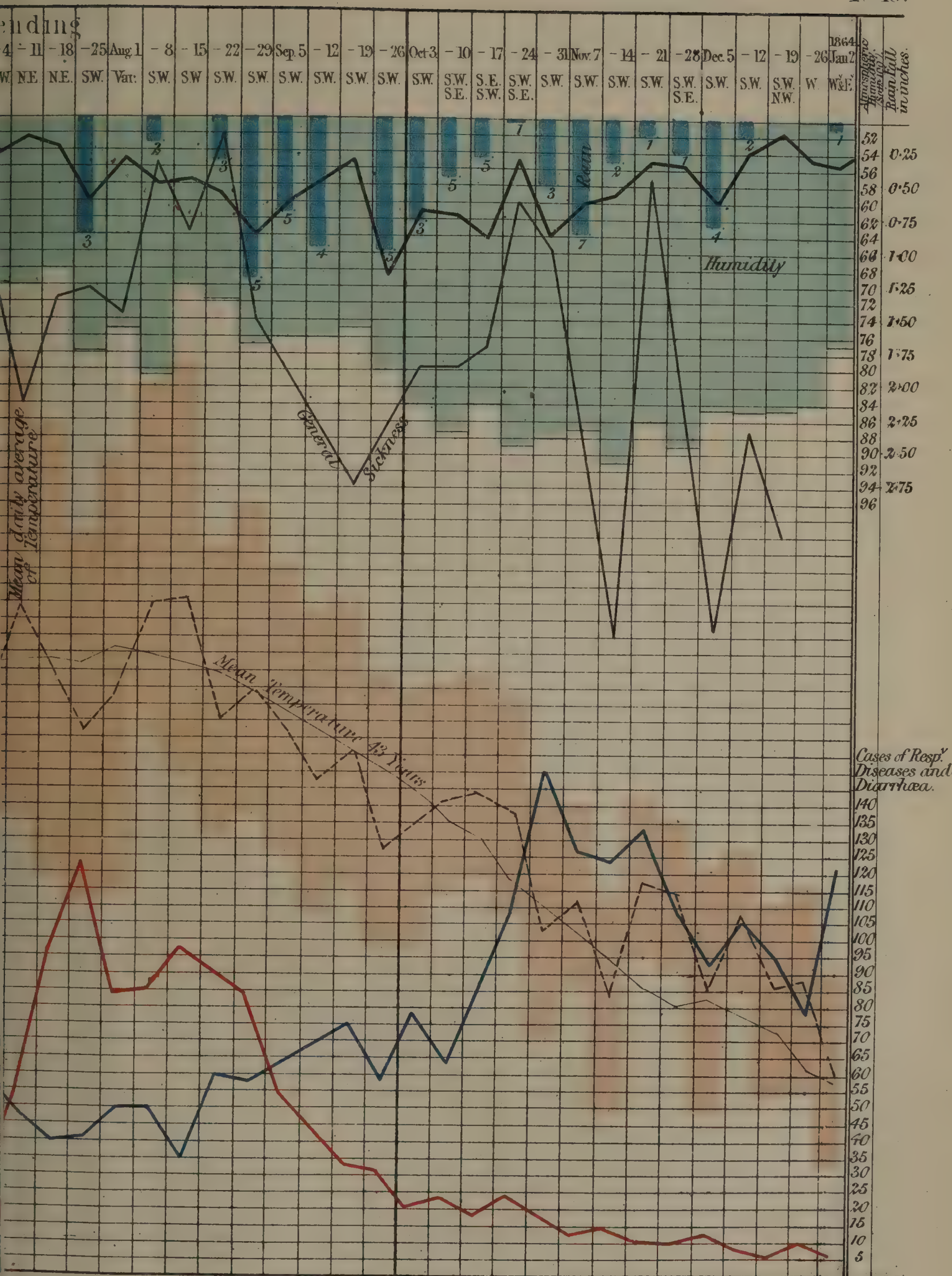
Vincent Brooks, Day & Son Lith. London W.C.



Wee
Cases of General Sickness
Wind
Bar.
Temp
Jan. 3 -10 -17 -24 -31 Feb. 7 -14 -21 -28 Mar. 7 -14 -21 -28 Apr. 4 -11 -18 -25 May 2 -9 -16 -23 -30 June 6 -13 -20
S.W. S.W. & S.E. N.E. S.W. S.W. S.W. Var. S.E. S.W. S.W. S.W. S.E. Var. N.E. S.W. N.W. Var. S.W. N.E. N.W. N.W. & N.E. N.E. S.W. N.E. N.E. & W. S.E. & S.W. S.W. W.S.W. & Var.
Barometer
Humidity
Rain
General Sickness
Mean Temperature
Diarrhœa.

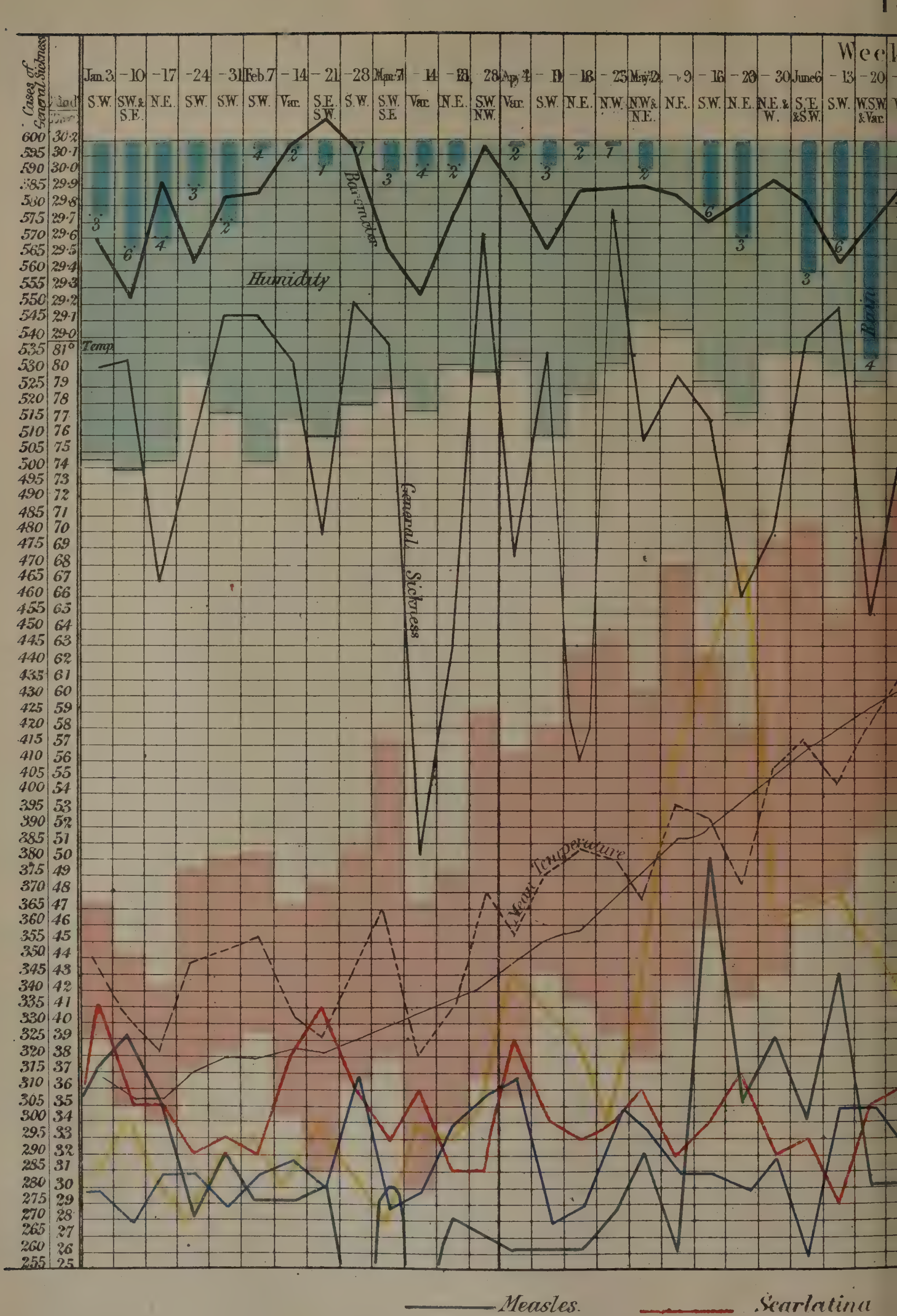
3.

No. 13.

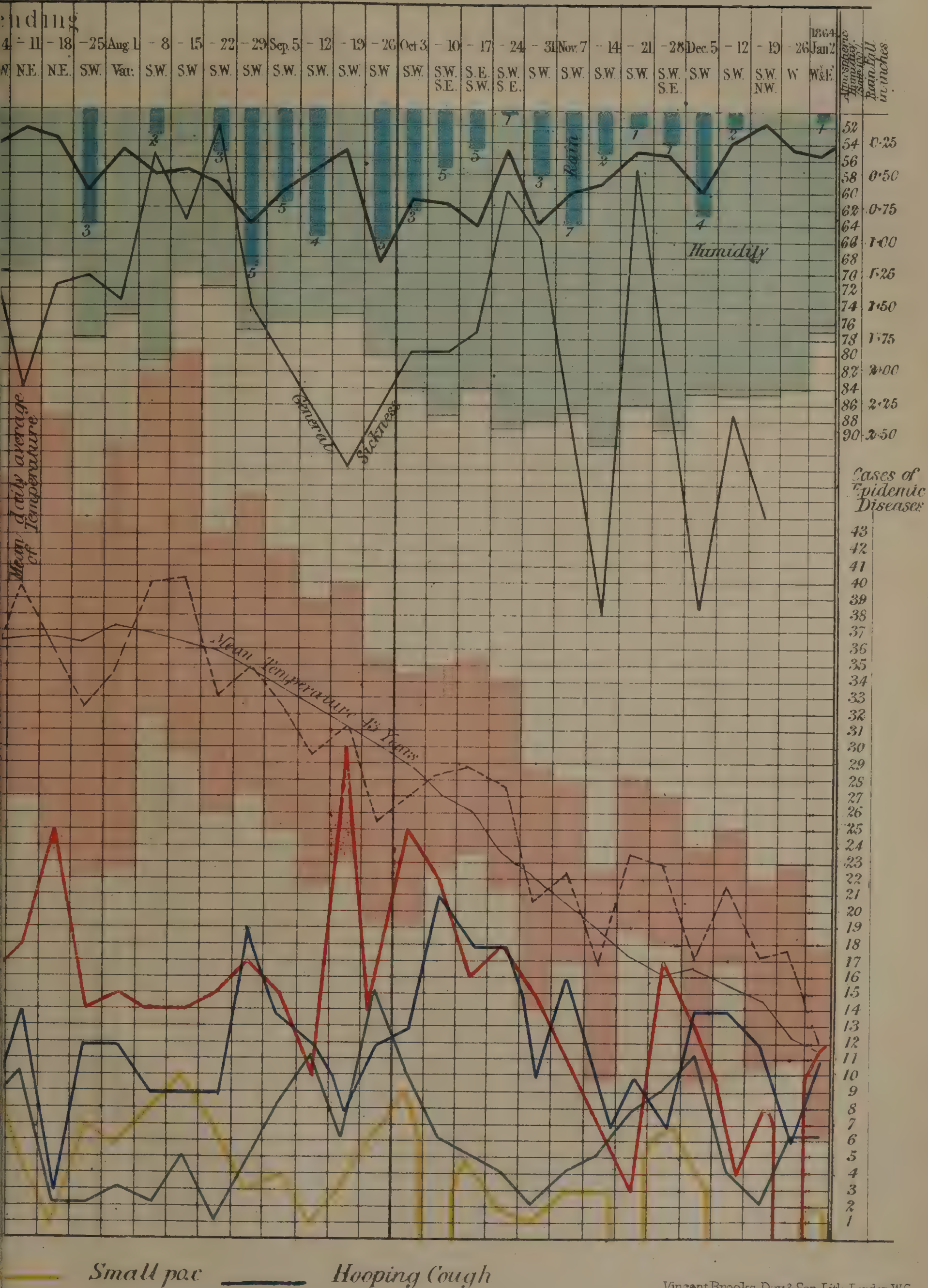


Respiratory diseases

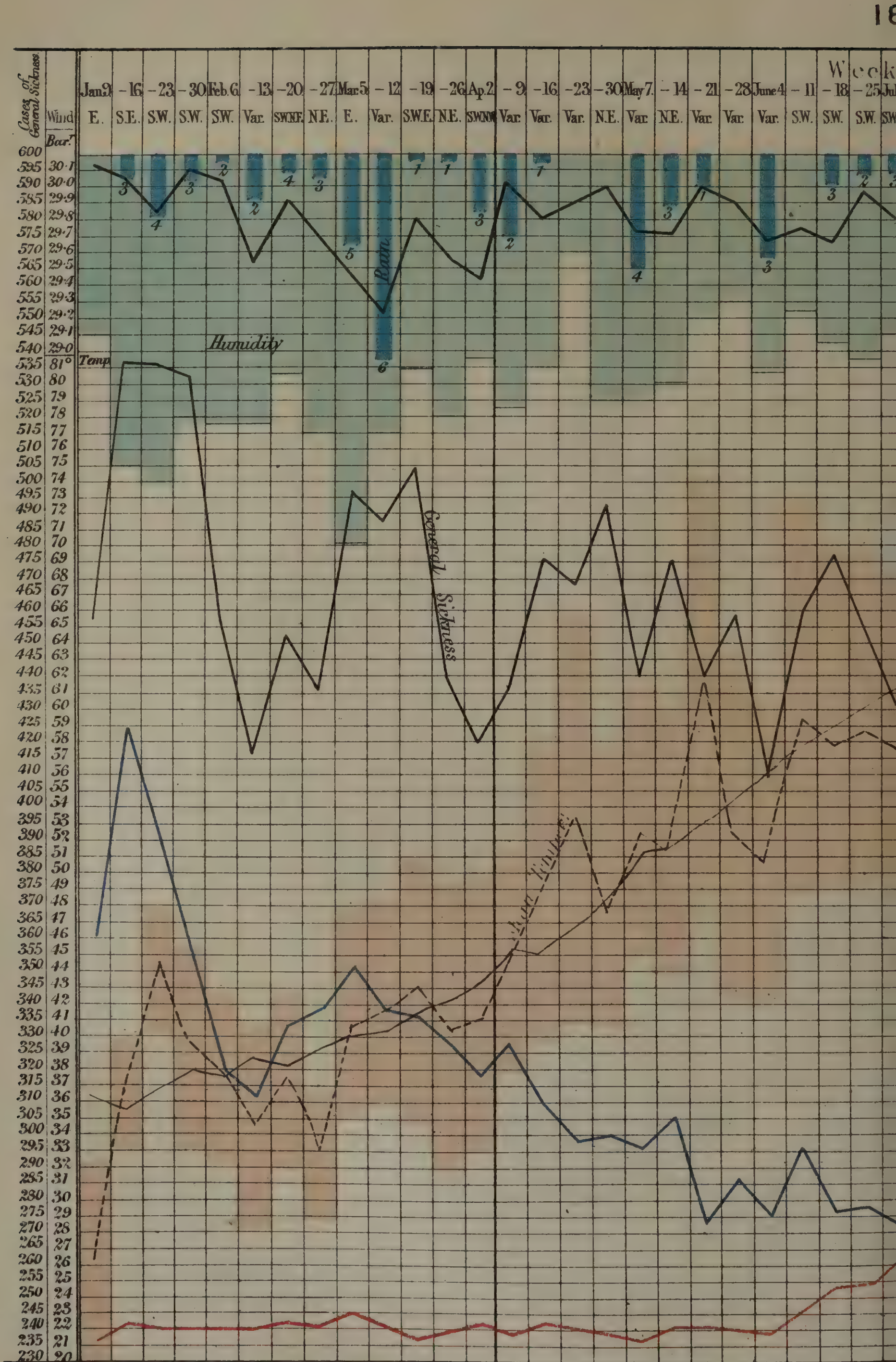
Vincent Brooks Day & Son, Lith. London W.C.



Week
Cases of General Sickness
Wind
Barometer
Humidity
Temp
General Sickness
Rain
Mean Temperature
Measles.
Scarlatina



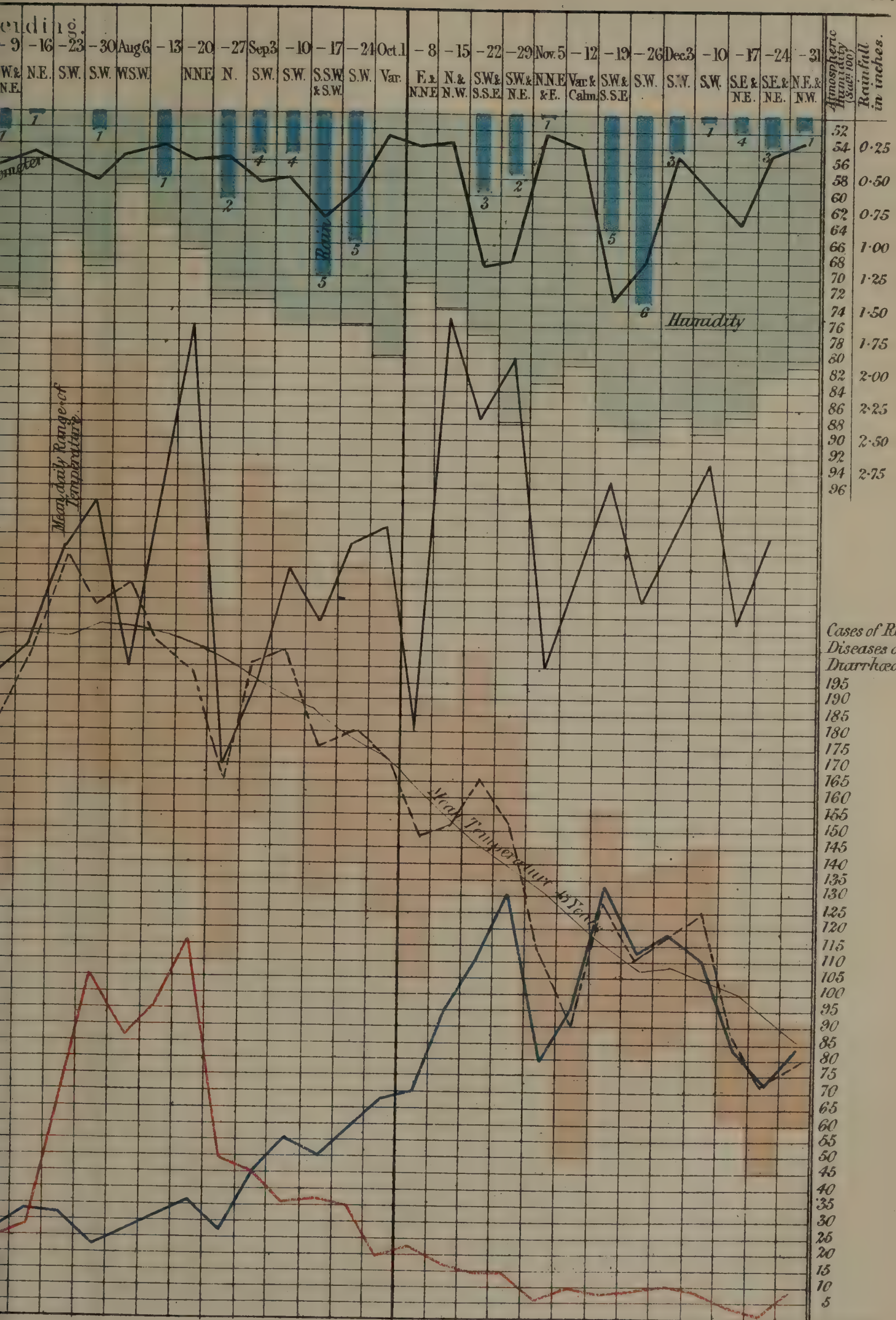
Vincent Brooks Day & Son Lith. London W.C.


18
Week
Cases of General Sickness
Wind
Bar.
Temp
Humidity
Rain
General Sickness
Jan 9
E.
S.E.
S.W.
Var.
N.E.
Feb. 6
Mar 5
Ap. 2
May 7
June 4

Diarrhœa

4.

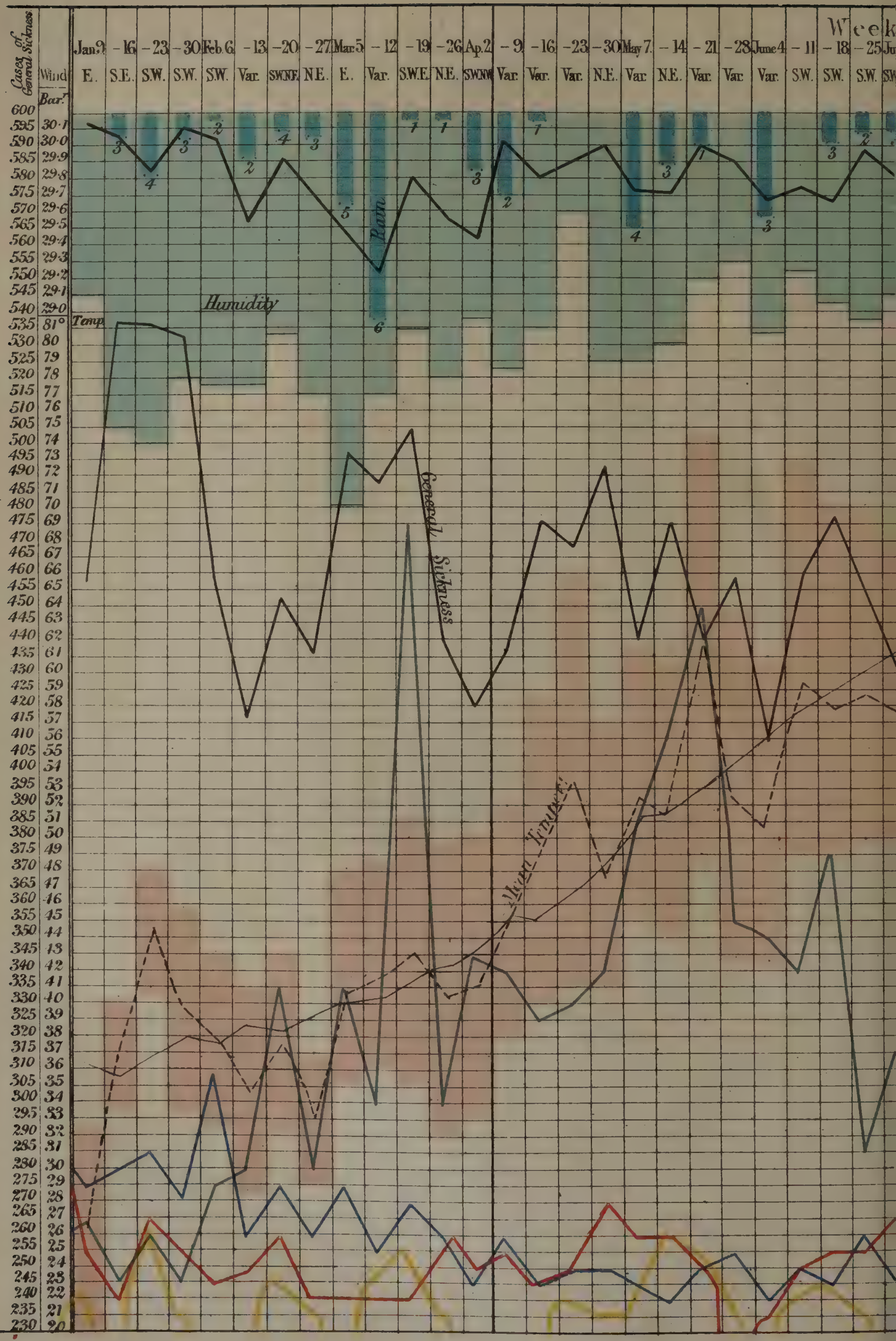
No. 15.



Respiratory diseases.

Vincent Brooks, Day & Son Lith. London W.C.

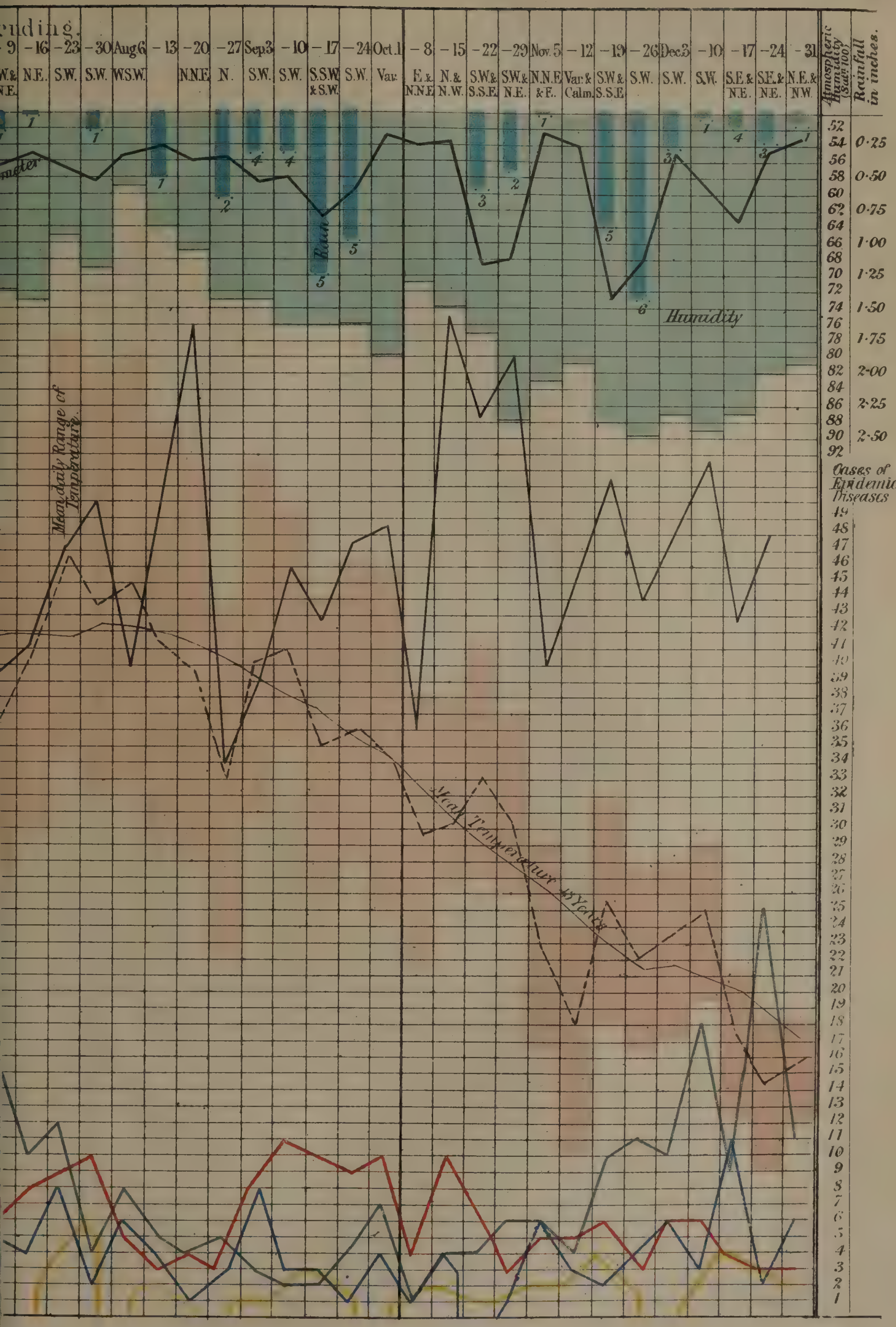
18



Measles
Scarlatina

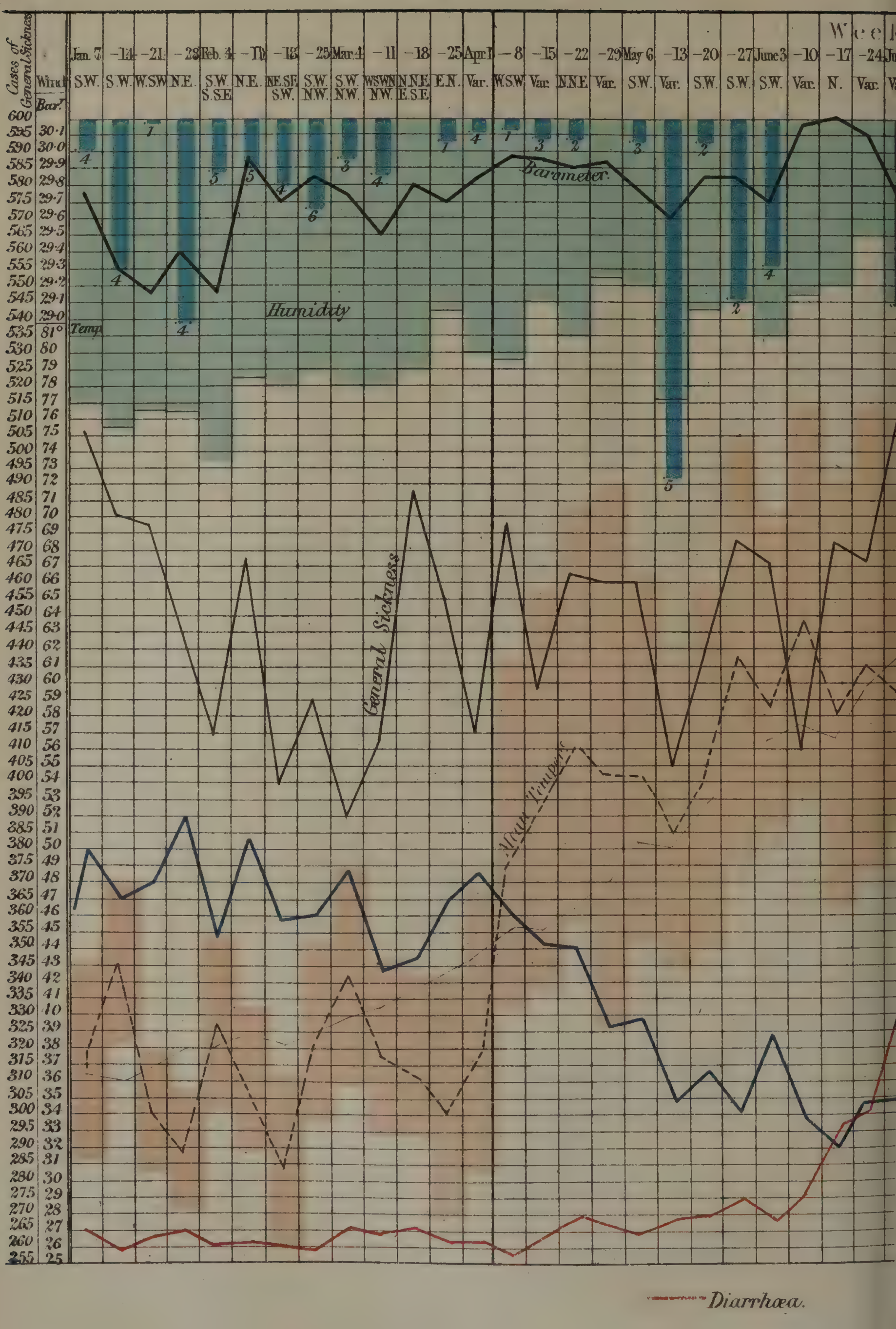
4.

N°. [illegible]



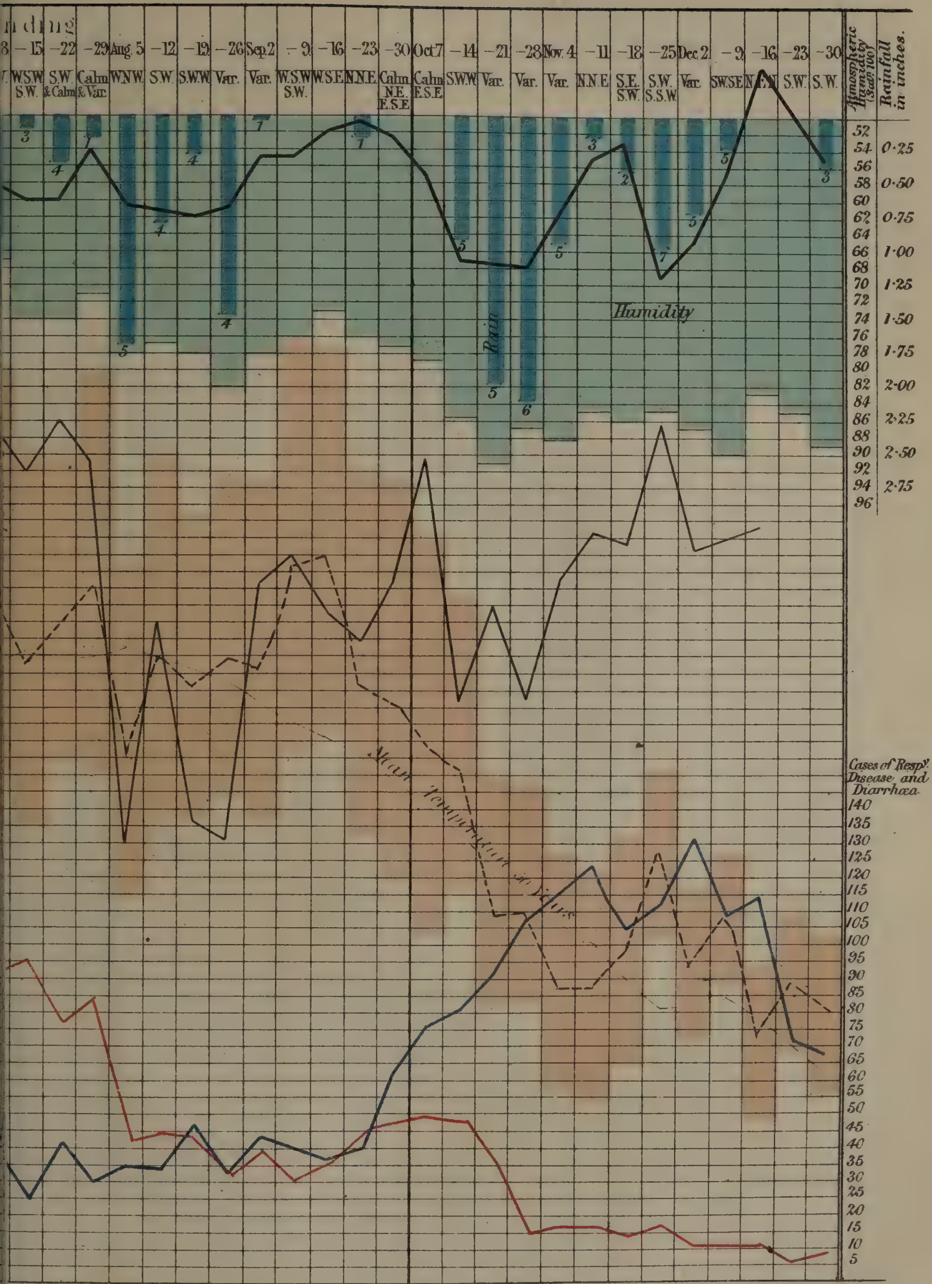
Small pox — Hooping Cough

Vincent Brooks Day & Son Lith. London W.C.


Cases of General Sickness
Wind
Barᵗ.
Temp.
Jan. 7 -14 -21 -28 Feb. 4 -11 -18 -25 Mar. 4 -11 -18 -25 Apr. 1 -8 -15 -22 -29 May 6 -13 -20 -27 June 3 -10 -17 -24
S.W. S.W. W.S.W. N.E. S.W. S.S.E. N.E. N.E. S.E. S.W. S.W. N.W. S.W. N.W. W.S.W. N.W. N.W. N.N.E. E.S.E. E.N. Var. W.S.W. Var. N.N.E. Var. S.W. Var. S.W. S.W. S.W. Var. N. Var.
Barometer.
Humidity
General Sickness
Mean Temperature
Diarrhœa.

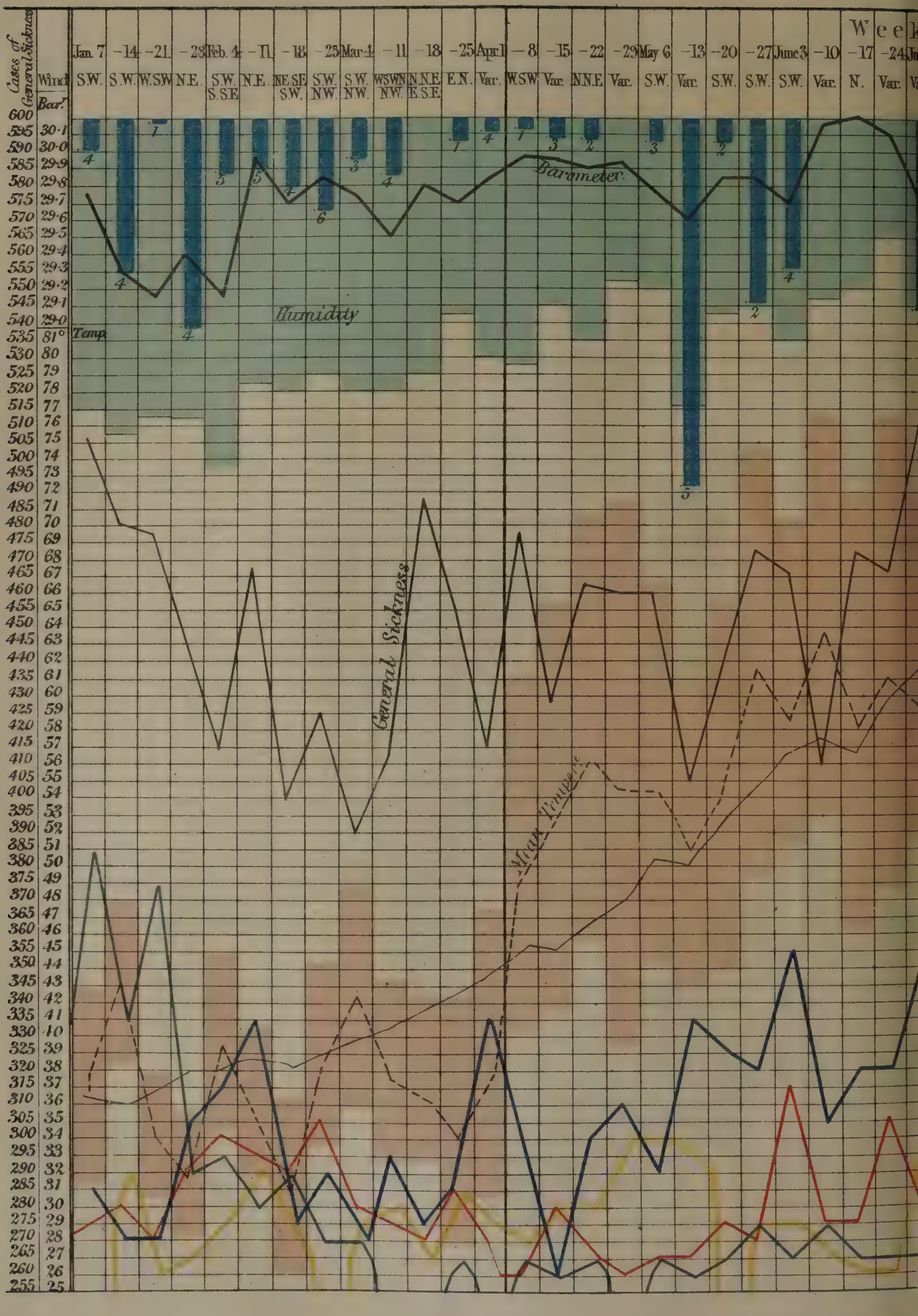
5.

No. 17.

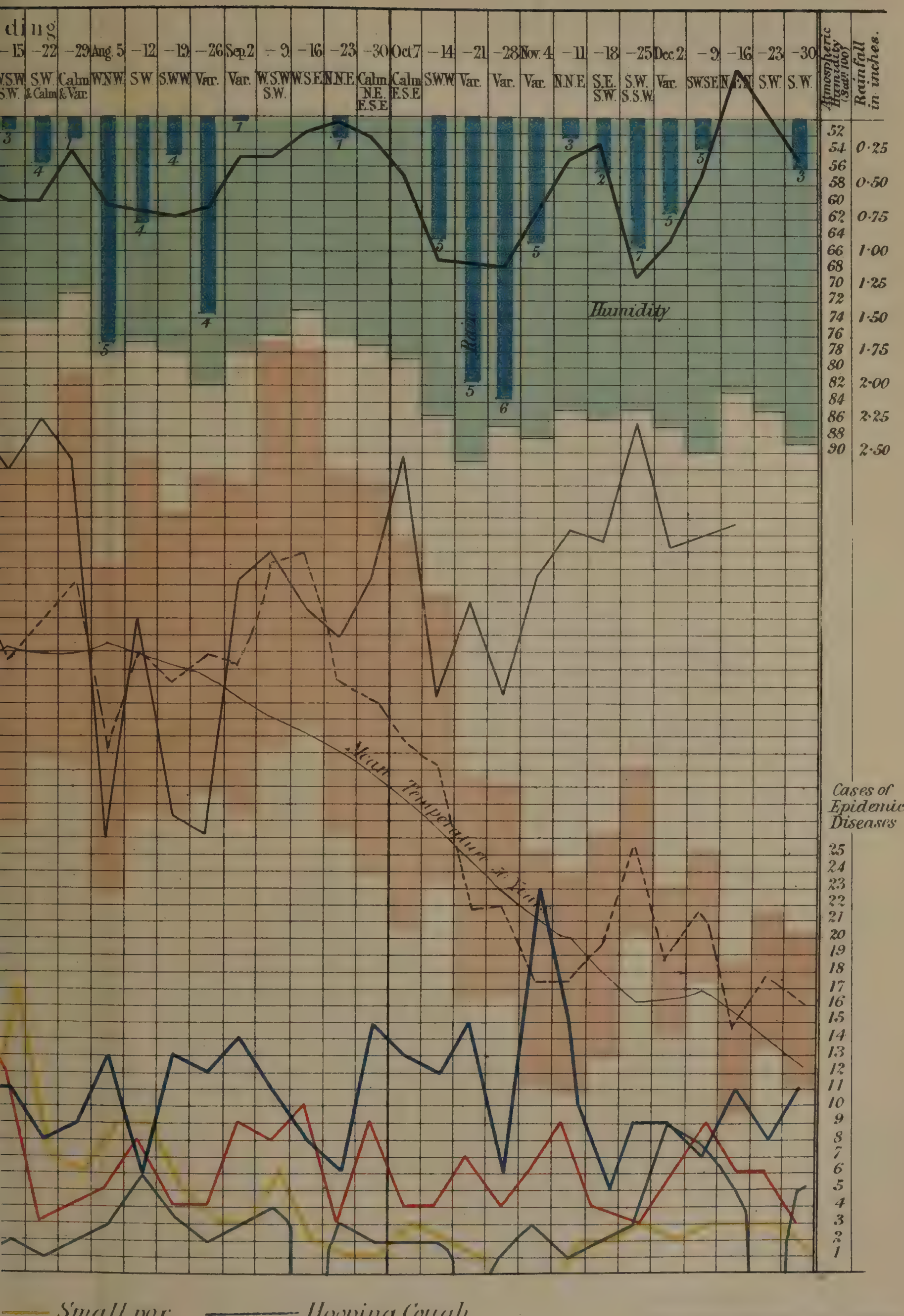


Respiratory Diseases.

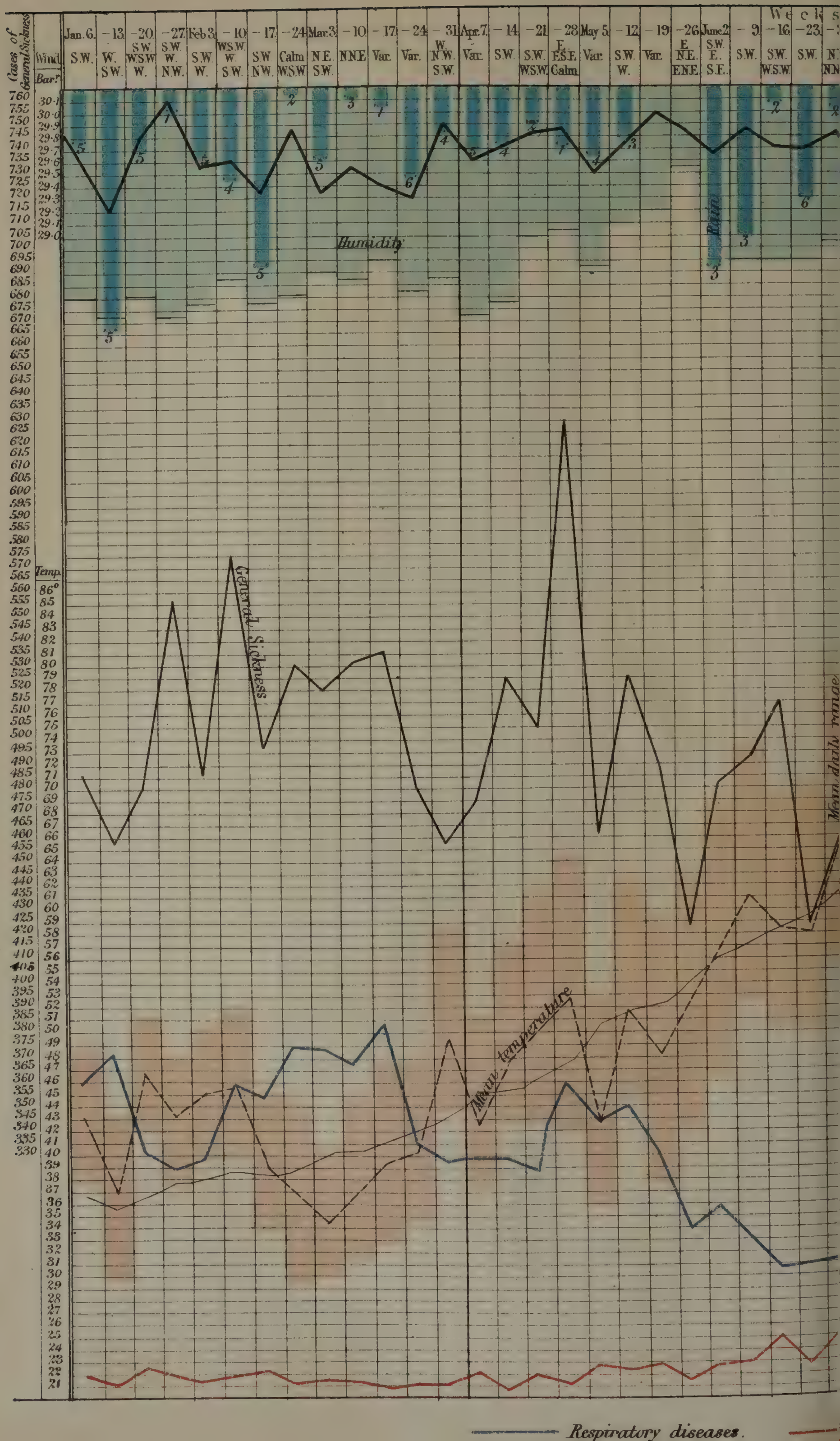
Vincent Brooks, Day & Son, Lith. London W.C.


Week
Cases of General Sickness
Wind
Bar.
Temp.
Jan. 7
-14
-21
-28
Feb. 4
-11
-18
-25
Mar. 4
-11
-18
-25
Apr. 1
-8
-15
-22
-29
May 6
-13
-20
-27
June 3
-10
-17
-24
Barometer
Humidity
General Sickness
Mean Temperature
Measles
Scarlatina

Nº 18.

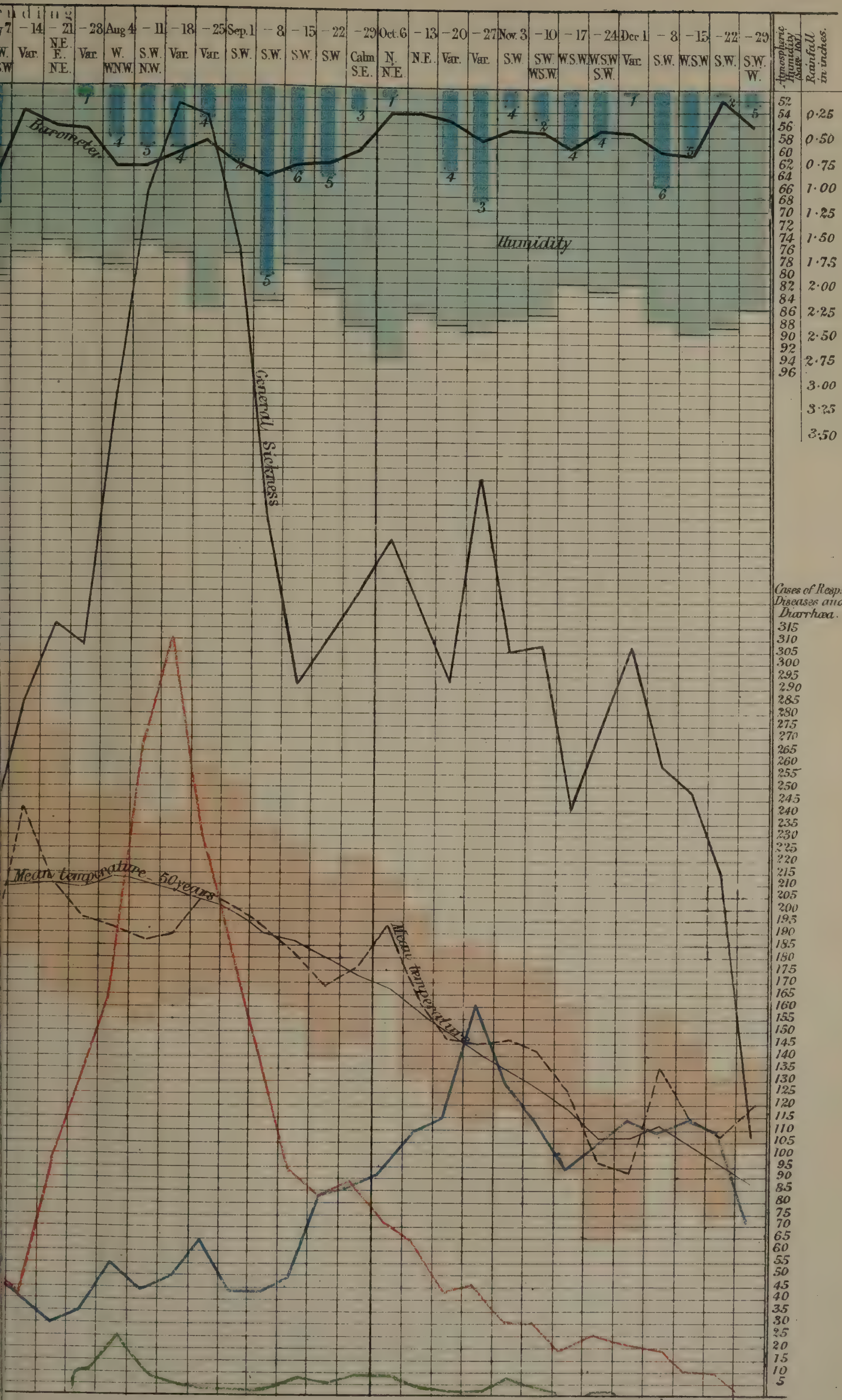


Vincent Brooks Day & Son Lith. London W.C.


Weeks
Cases of General Sickness
Wind
Bar.
Temp.
Jan. 6. S.W.
-13. W. S.W.
-20. S.W. W.S.W. W.
-27. S.W. W. N.W.
Feb 3. S.W. W.
-10. W.S.W. W. S.W.
-17. S.W. N.W.
-24. Calm W.S.W.
Mar. 3. N.E. S.W.
-10. N.N.E.
-17. Var.
-24. Var.
-31. W. N.W. S.W.
Apr. 7. Var.
-14. S.W.
-21. S.W. W.S.W.
-28. E. E.S.E. Calm
May 5. Var.
-12. S.W. W.
-19. Var.
-26. E. N.E. E.N.E.
June 2. S.W. E. S.E.
-9. S.W.
-16. S.W. W.S.W.
-23. S.W.
Humidity
Rain
General Sickness
Mean temperature
Mean daily range
Respiratory diseases.

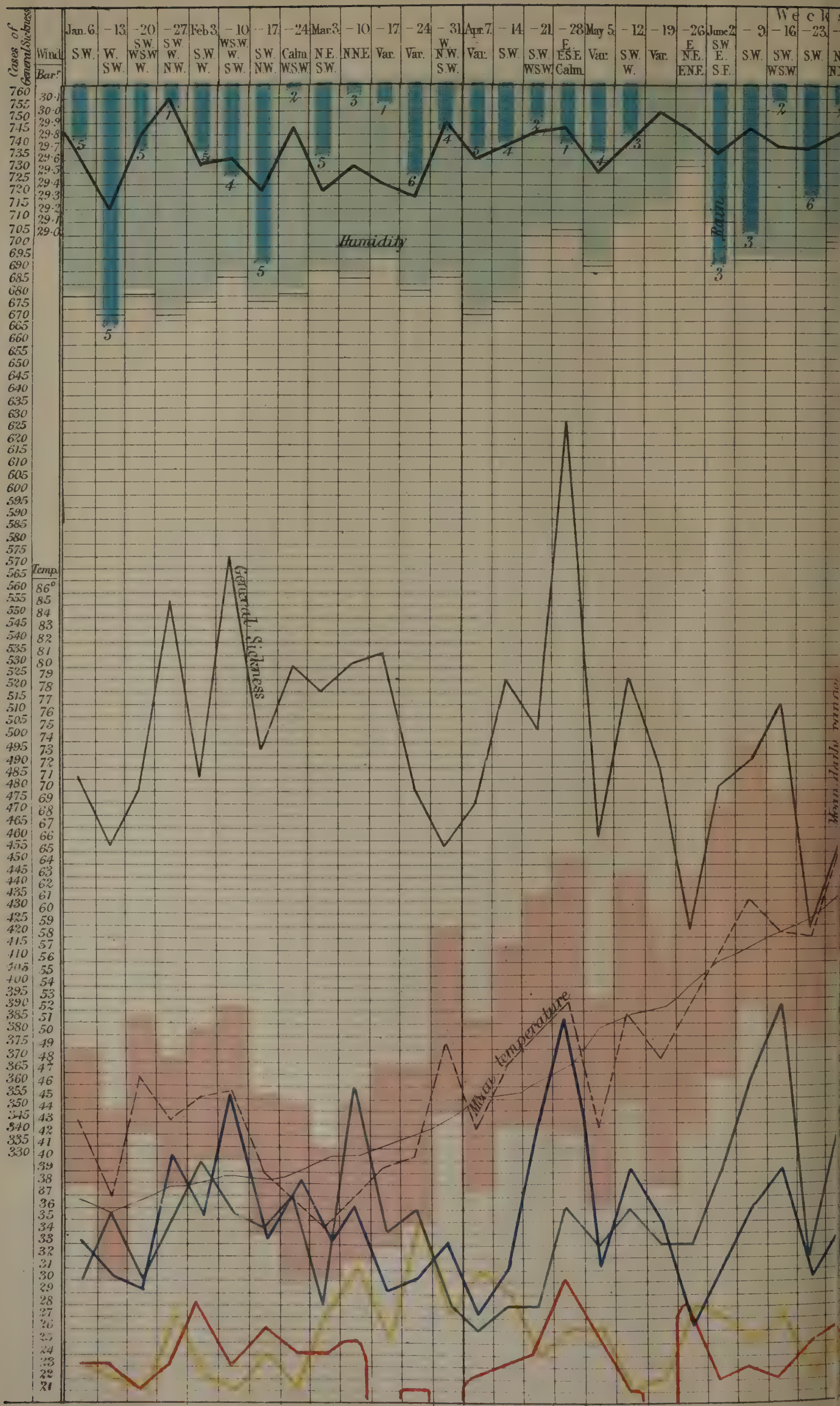
6.

No. 19.

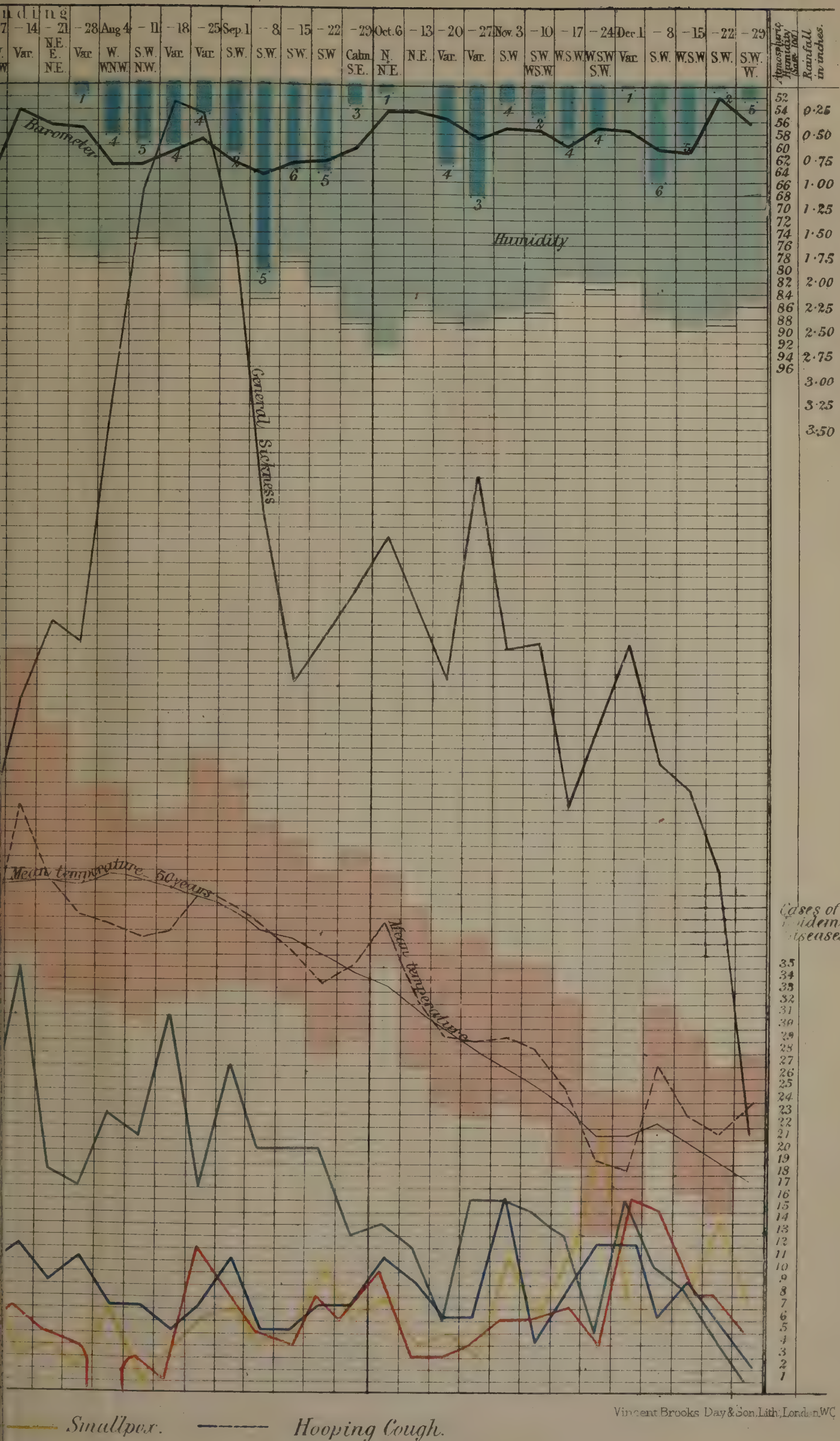


rrhœa. ——— Cholera.

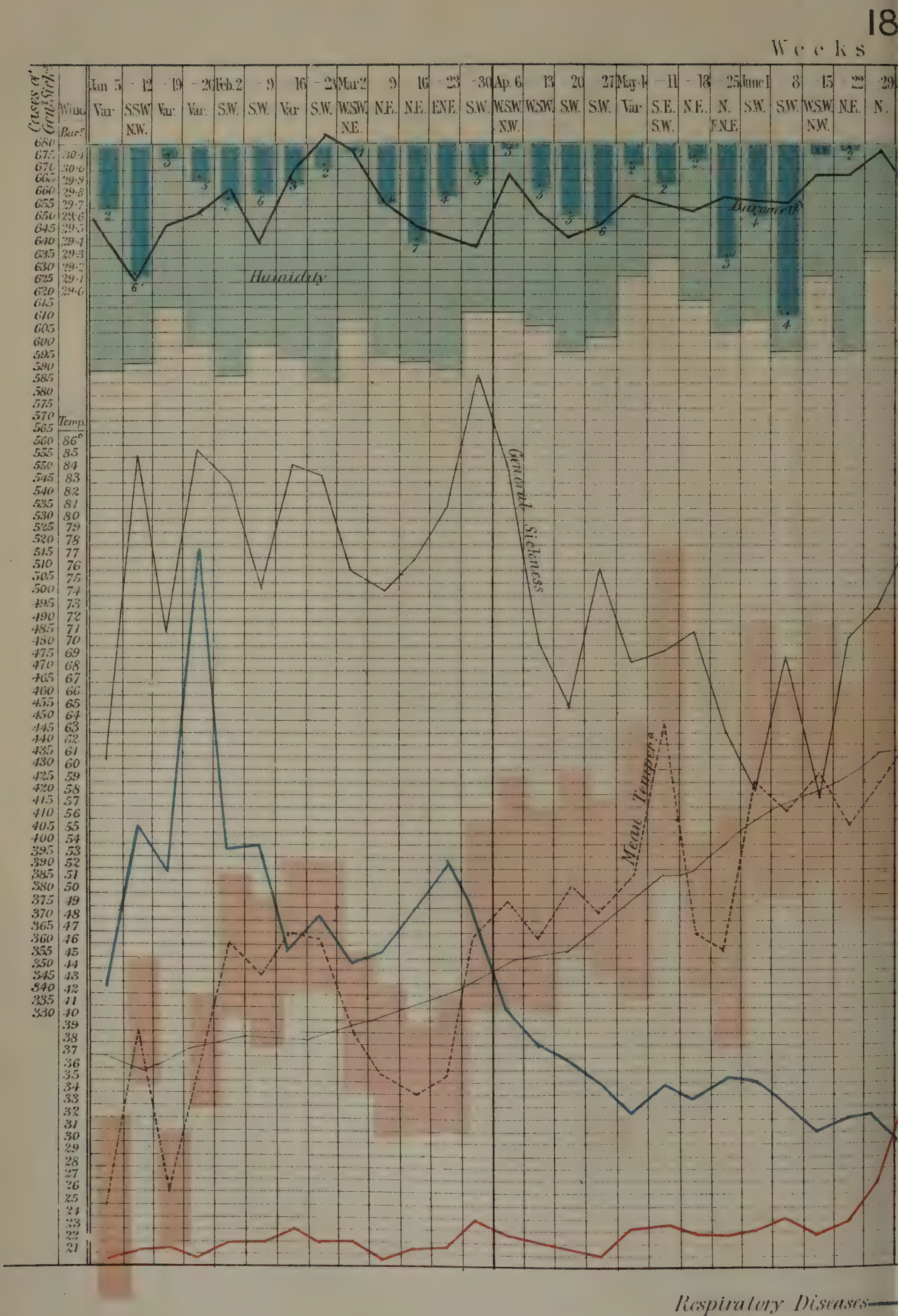
Vincent Brooks, Day & Son, Lith. London WC



Measles. Scarlatina.



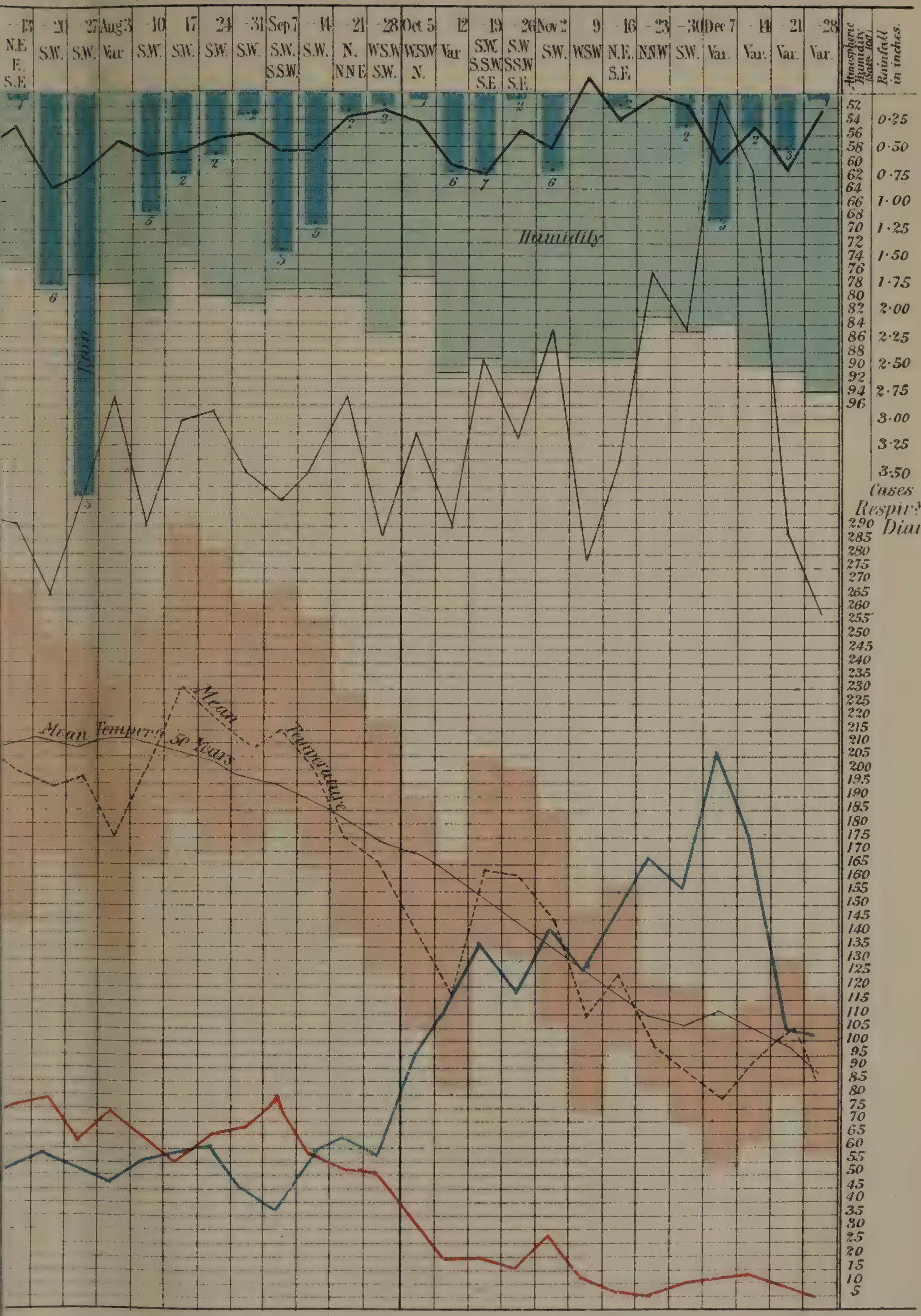
Vincent Brooks Day & Son, Lith; London WC


18
Weeks
Cases of Gen! Sick.
Wind
Bar!
Temp.
Jan 5 · 12 · 19 · 26 · Feb. 2 · 9 · 16 · 23 · Mar 2 · 9 · 16 · 23 · 30 · Ap. 6 · 13 · 20 · 27 · May 4 · 11 · 18 · 25 · June 1 · 8 · 15 · 22 · 29
Var. · SSW N.W. · Var. · Var. · S.W. · S.W. · Var. · S.W. · W.S.W. N.E. · N.E. · N.E. · E.N.E. · S.W. · W.S.W. N.W. · W.S.W. · S.W. · S.W. · Var. · S.E. S.W. · N.E. · N. E.N.E. · S.W. · S.W. · W.S.W. N.W. · N.E. · N.
Humidity
Barometer
General Sickness
Mean Temper.
Respiratory Diseases

7.

ending.

Nº 21.

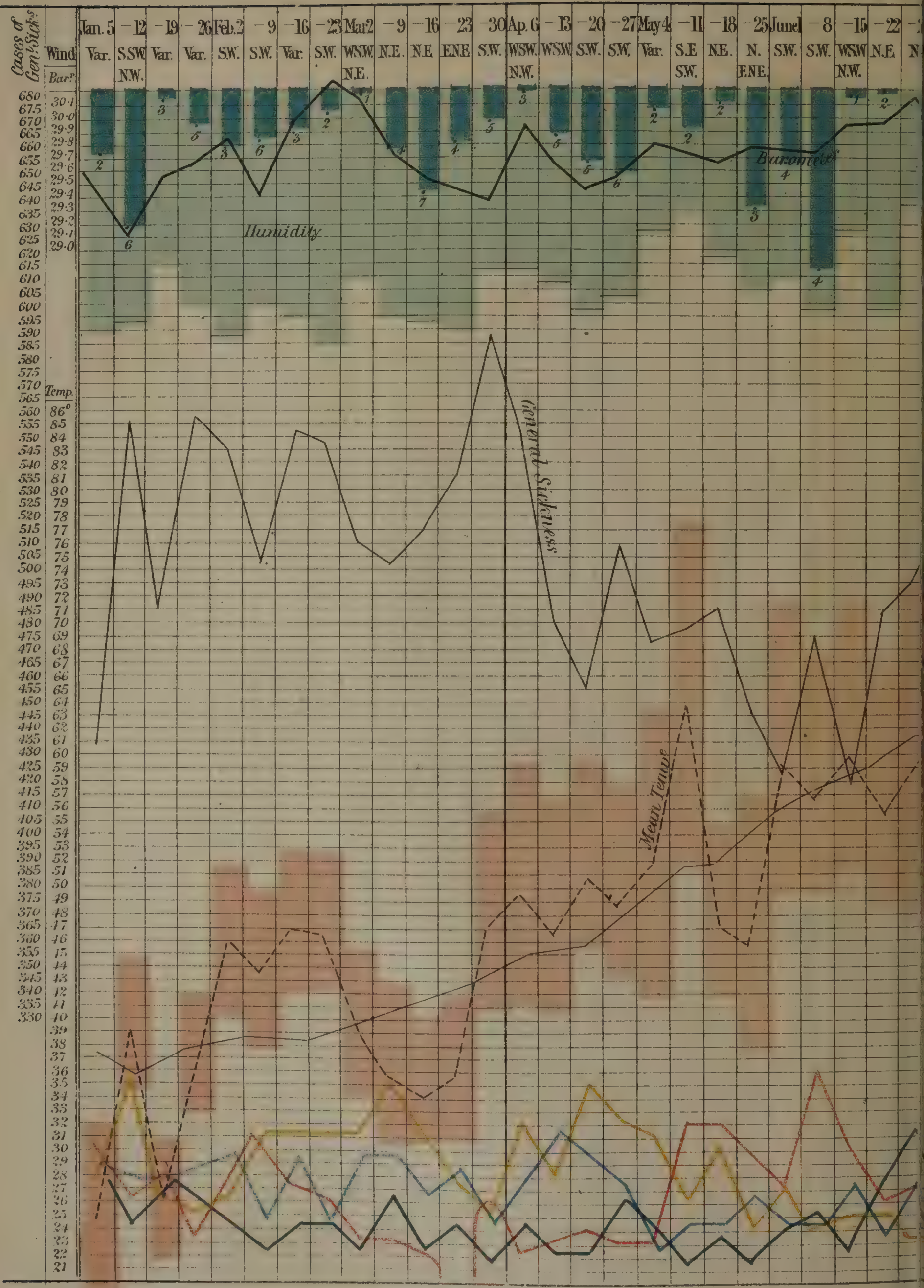


Vincent Brooks, Day & Son Lith. London WC

Diarrhœa

1[illegible]

Weeks



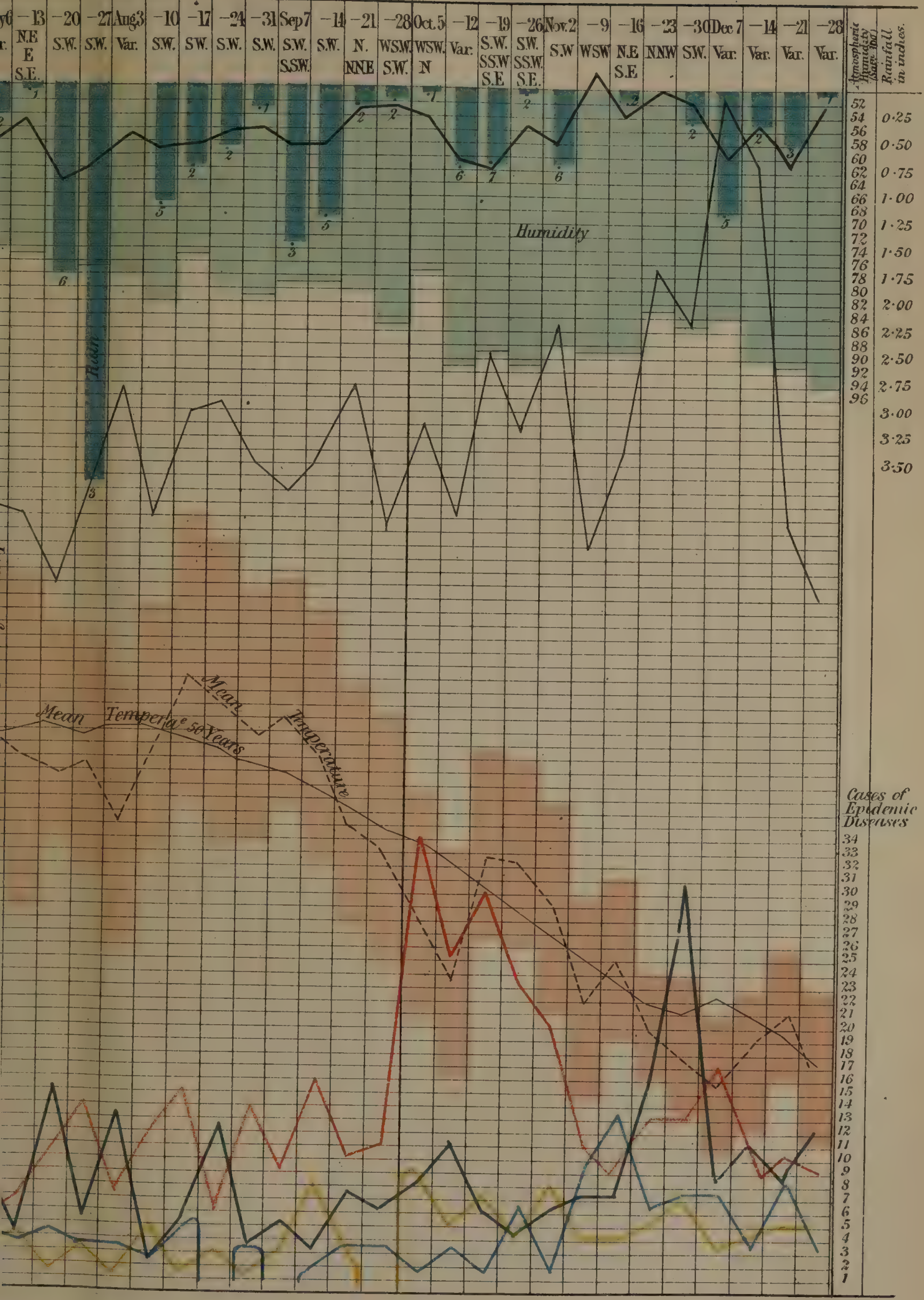
Measles.

Scarlatina.

67.

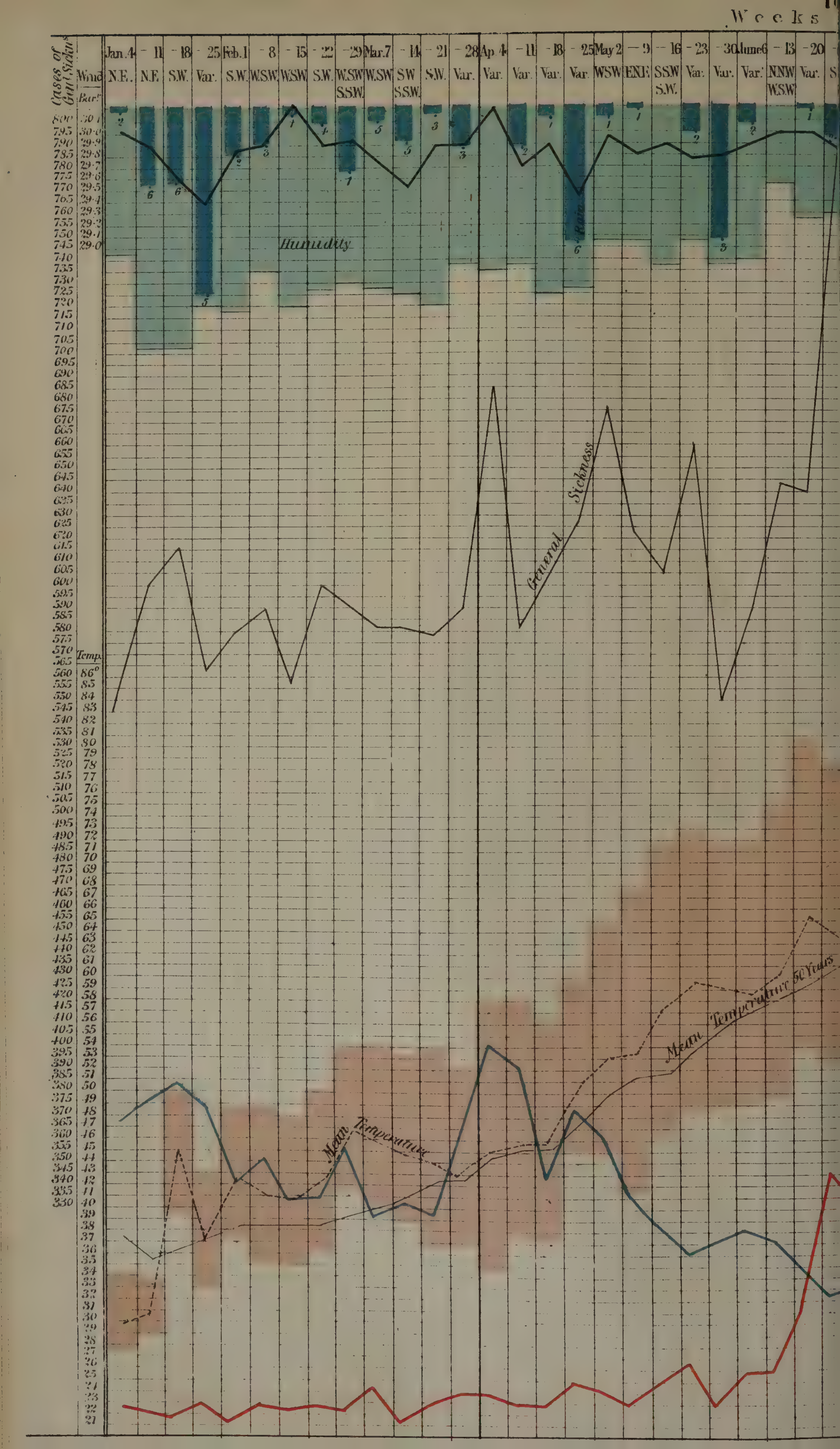
ending.

No. 22.



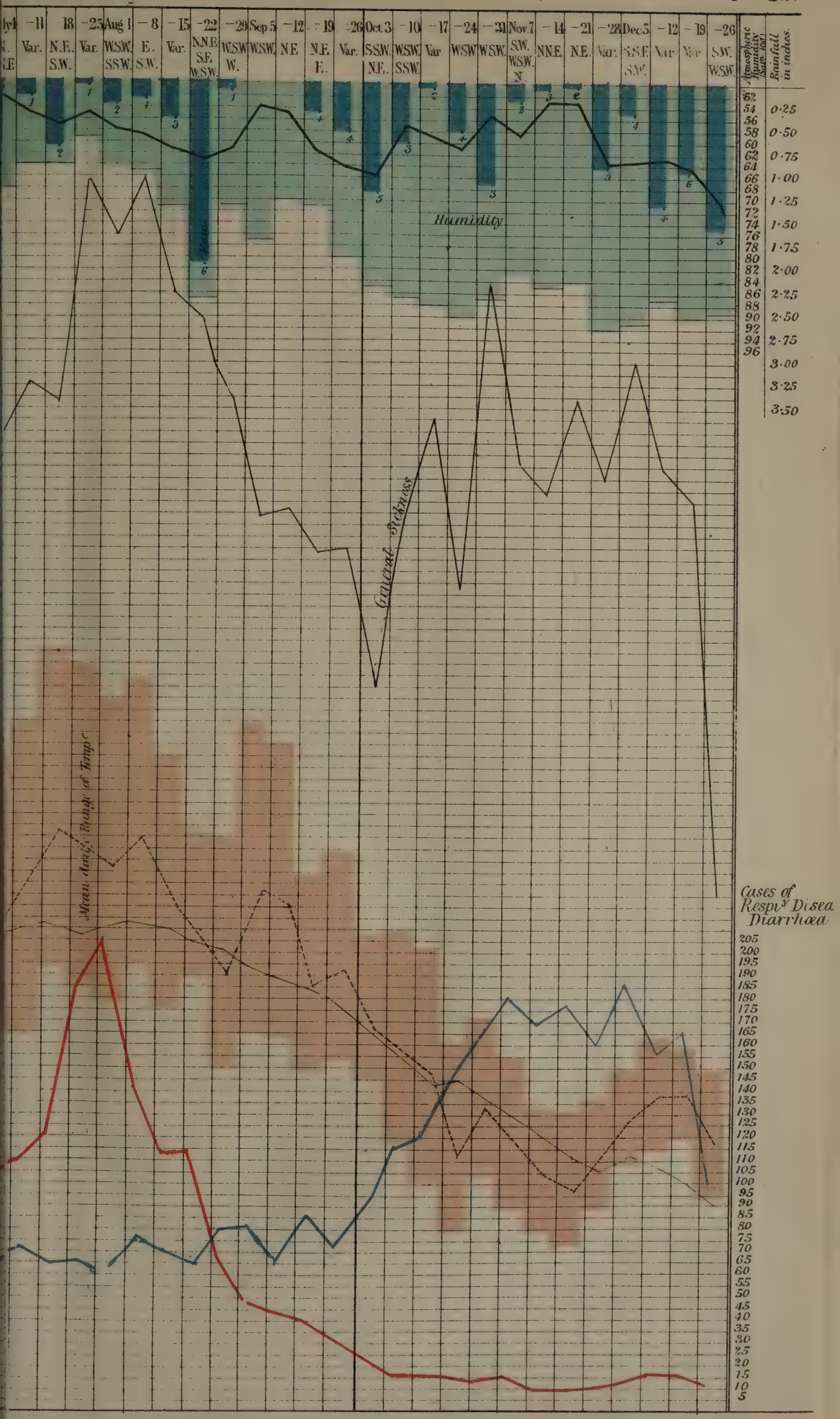
Smallpox Hooping Cough.

Vincent Brooks Day & Son Lith, London W.C.



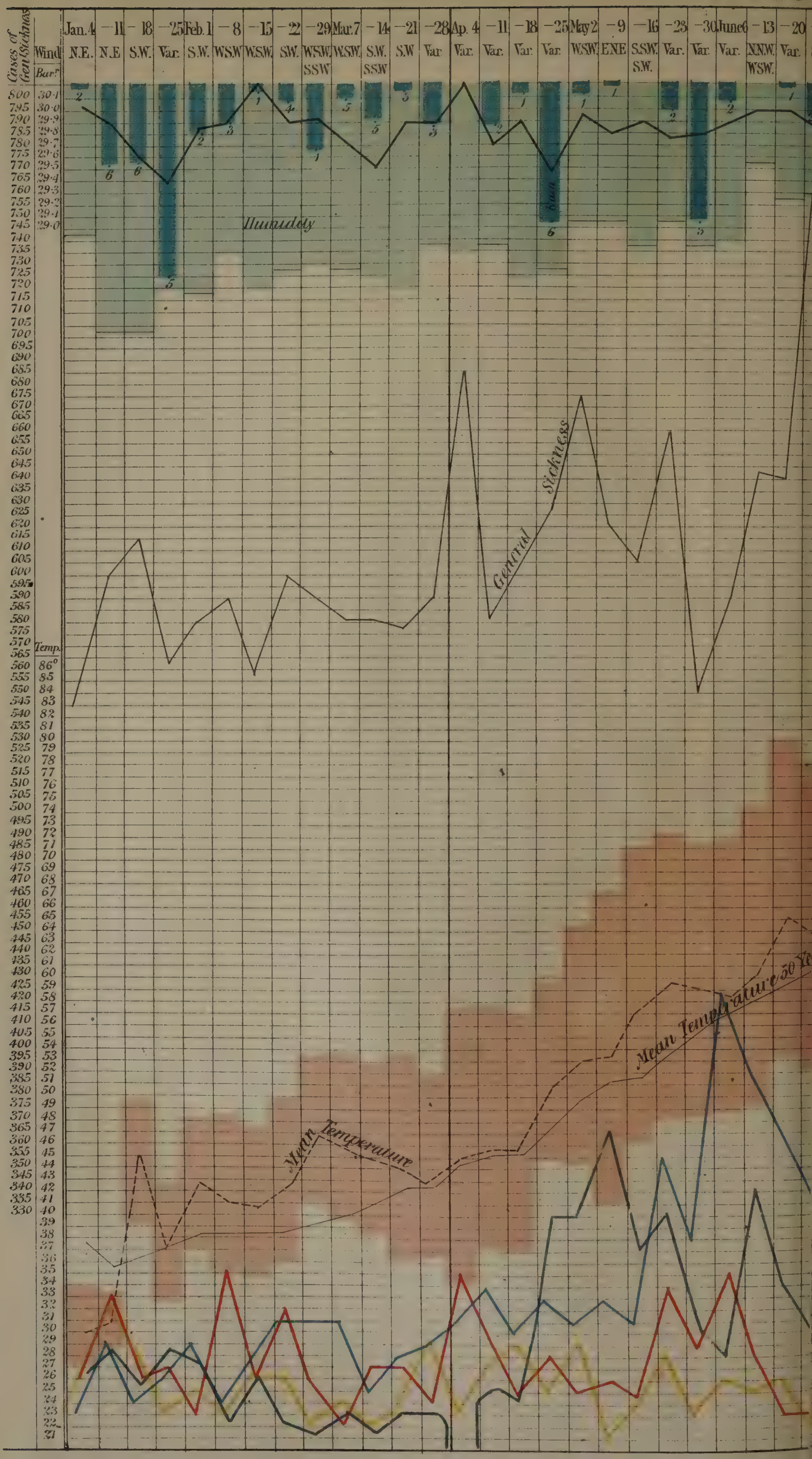
Weeks
Cases of Genl. Sickness
Wind
Bar.
Temp.
Jan. 4
11
18
25
Feb. 1
8
15
22
29
Mar. 7
14
21
28
Ap. 4
11
18
25
May 2
9
16
23
30
June 6
13
20
Humidity
Rain
General Sickness
Mean Temperature
Mean Temperature 50 Years

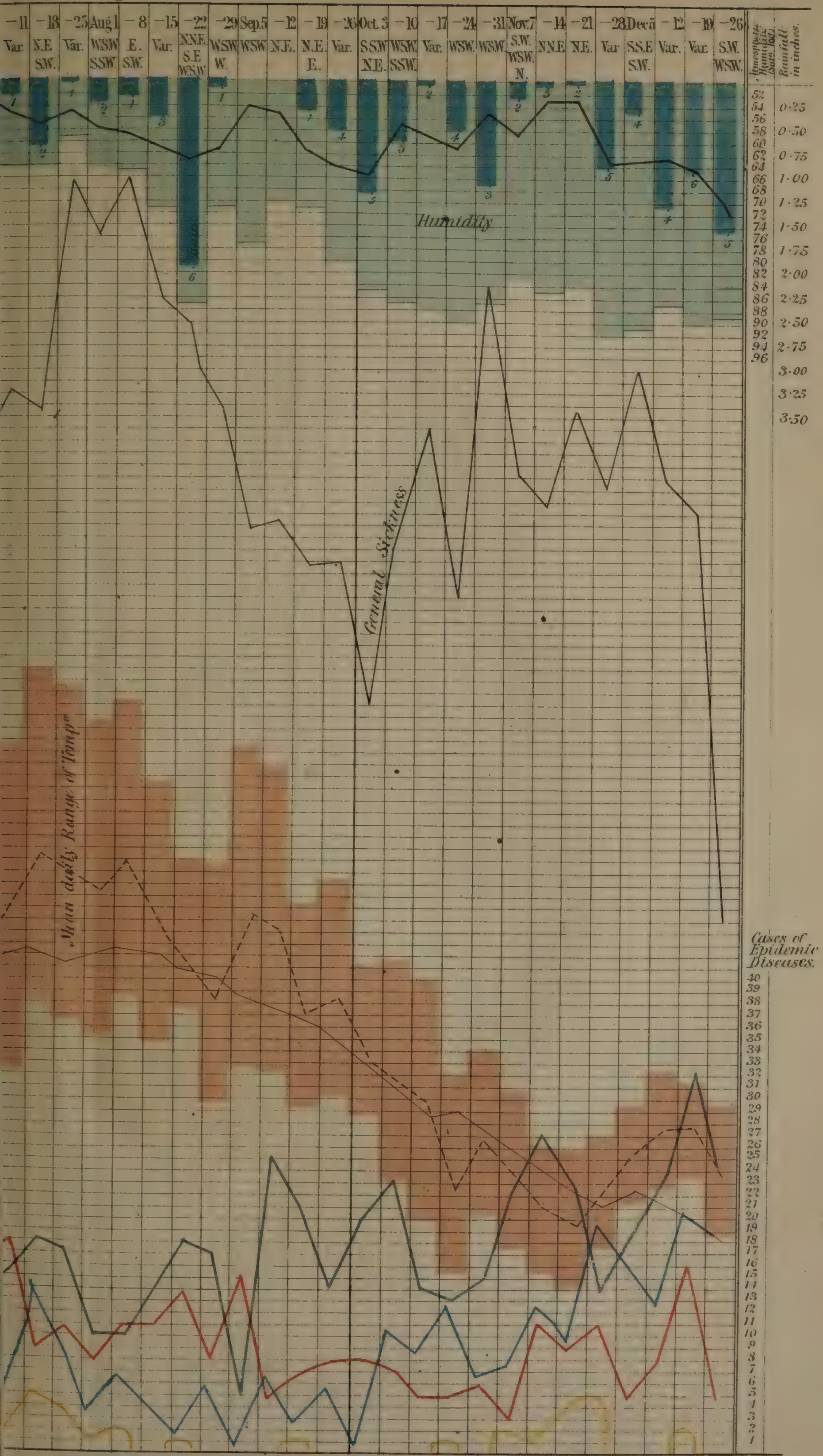
ending. N° 23.



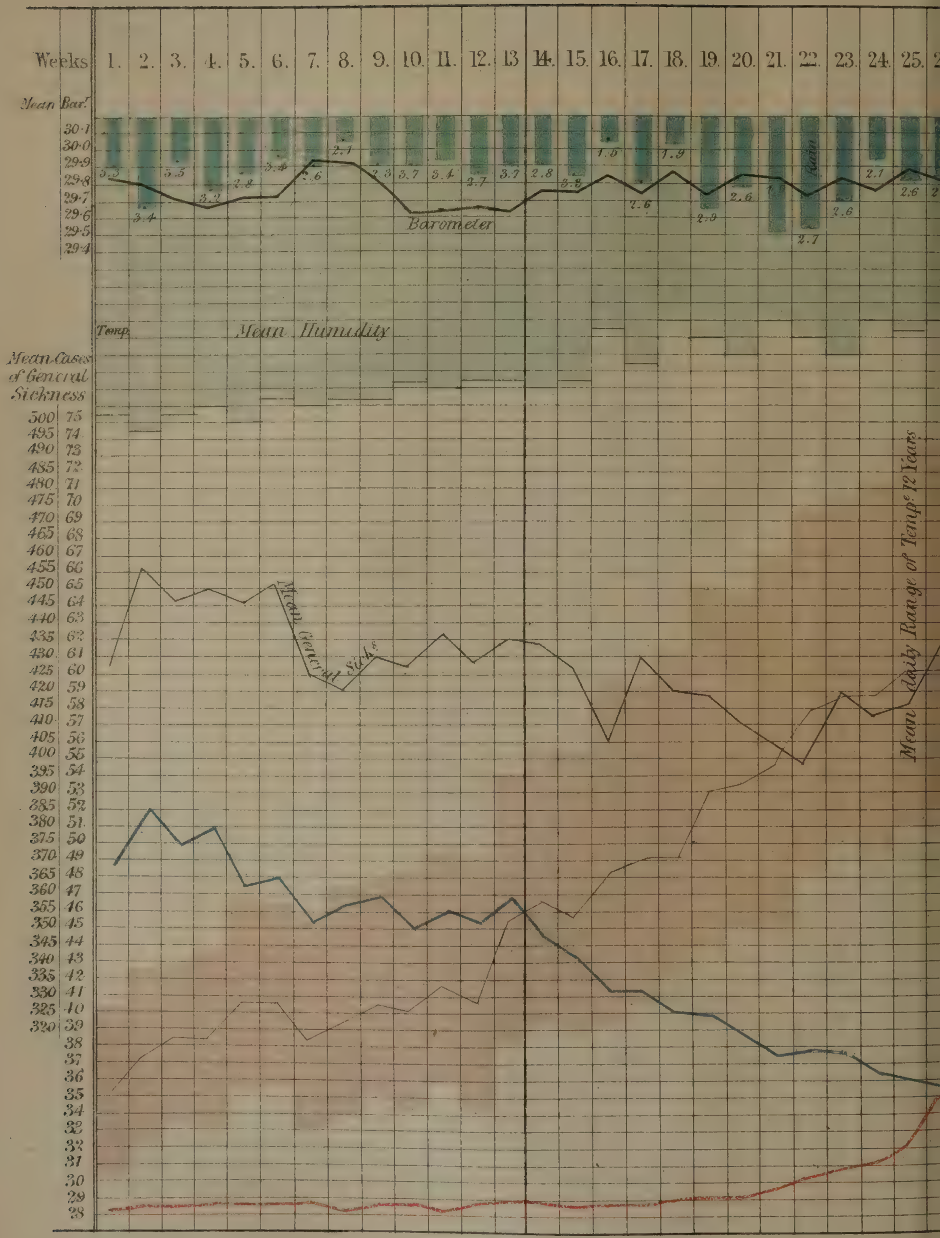
Jly 4
-11
-18
-25
Aug 1
-8
-15
-22
-29
Sep 5
-12
-19
-26
Oct 3
-10
-17
-24
-31
Nov. 7
-14
-21
-28
Dec. 5
-12
-19
-26
Var.
N.E. S.W.
W.S.W. S.S.W.
E. S.W.
N.N.E. S.E. W.S.W.
W.S.W. W.
N.E.
S.S.W. N.E.
W.S.W. S.S.W.
S.W. W.S.W. N.
N.N.E.
S.S.E. S.W.
S.W. W.S.W.
Atmospheric Humidity (Satn. 100)
Rainfall in inches.
0·25
0·50
0·75
1·00
1·25
1·50
1·75
2·00
2·25
2·50
2·75
3·00
3·25
3·50
Humidity
General Sickness
Mean Daily Range of Temp.
Cases of Respiy Disea Diarrhœa

W e e k s


Cases of Gen! Sickness
Wind
Bar!
Temp.
Jan. 4
-11
-18
-25
Feb. 1
-8
-15
-22
-29
Mar. 7
-14
-21
-28
Ap. 4
-11
-18
-25
May 2
-9
-16
-23
-30
June 6
-13
-20
N.E.
N.E
S.W.
Var.
S.W.
W.S.W
W.S.W.
S.W.
W.S.W. S.S.W
W.S.W.
S.W. S.S.W
S.W
Var.
Var.
Var.
Var.
Var.
W.S.W.
E.N.E
S.S.W. S.W.
Var.
Var.
Var.
N.N.W. W.S.W.
Var.
Humidity
General Sickness
Mean Temperature
Mean Temperature 50 Ye


-11
Var.
-18
N.E.
S.W.
-25
Var.
Aug 1
WSW
SSW.
-8
E.
S.W.
-15
Var.
-22
N.N.E.
S.E.
W.S.W.
-29
WSW
W.
Sep.5
WSW
-12
N.E.
-19
N.E.
E.
-26
Var.
Oct. 3
S.S.W.
N.E.
-10
W.S.W.
S.S.W.
-17
Var.
-24
WSW.
-31
WSW.
Nov. 7
S.W.
WSW.
N.
-14
N.N.E.
-21
N.E.
-28
Var.
Dec 5
S.S.E.
S.W.
-12
Var.
-19
Var.
-26
S.W.
WSW.
Rainfall in inches
0·25
0·50
0·75
1·00
1·25
1·50
1·75
2·00
2·25
2·50
2·75
3·00
3·25
3·50
Humidity
General Sickness
Mean daily Range of Temp.
Cases of Epidemic Diseases.

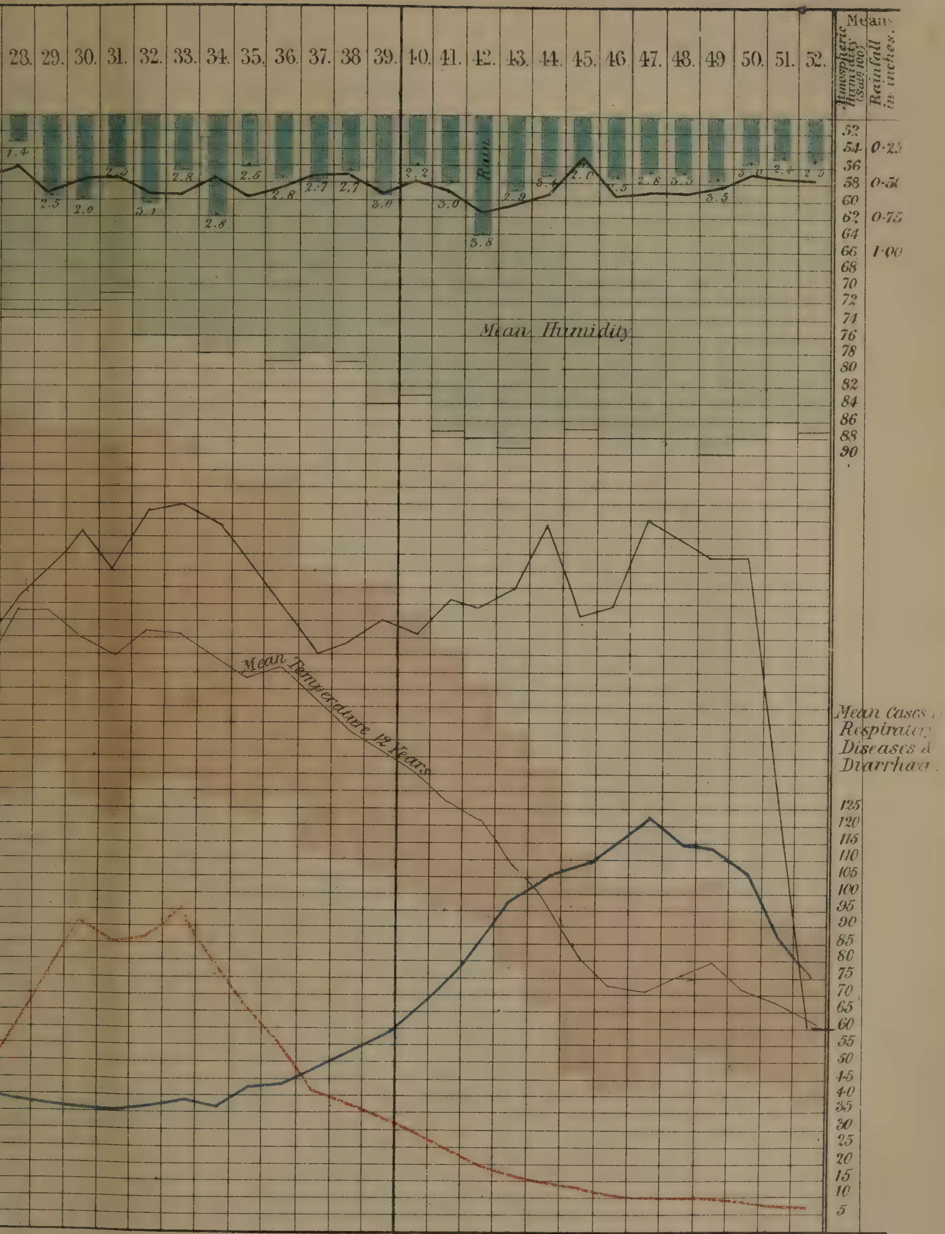
SUMMARY



Diarrhœa.

12 YEARS.

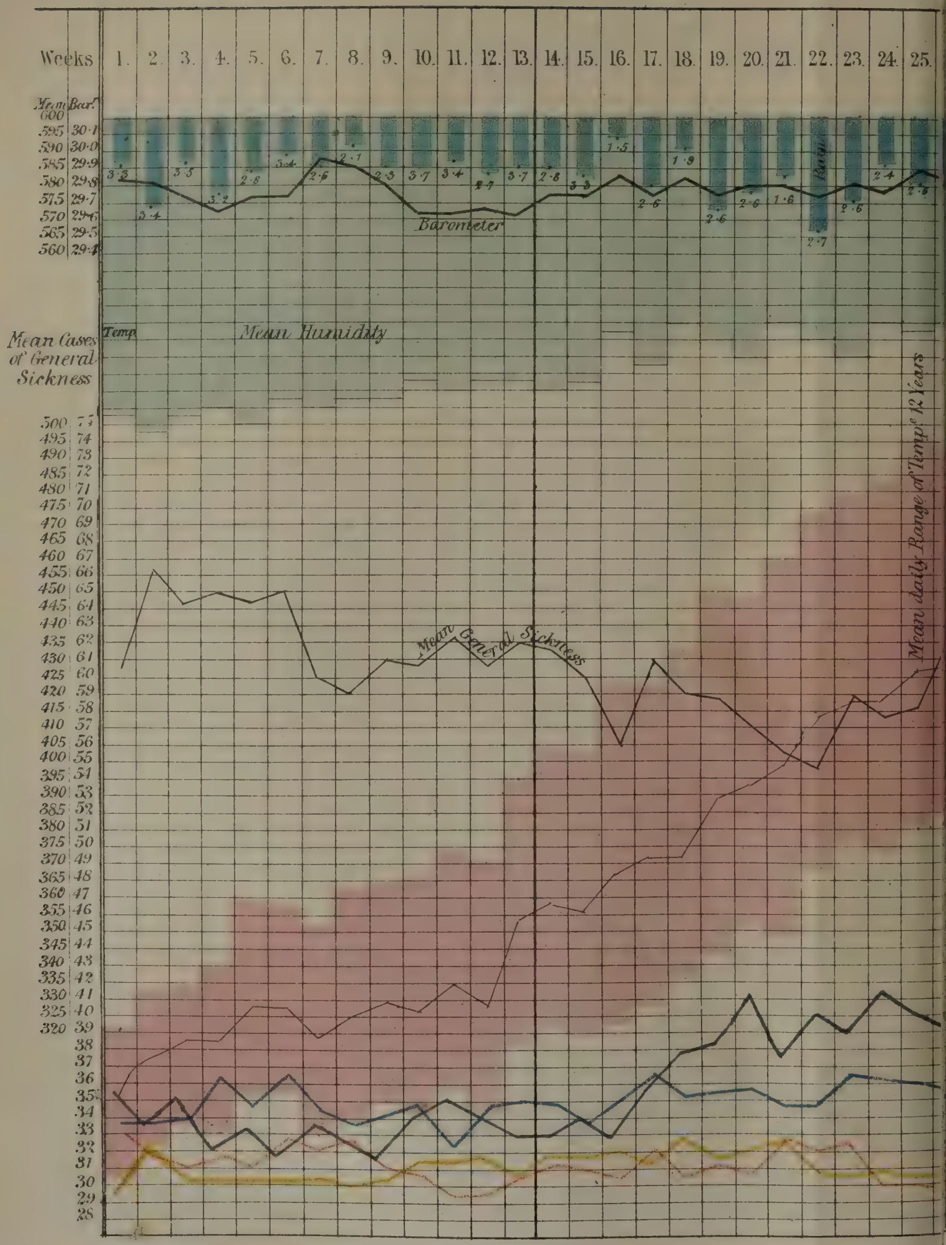
Nº 25



——Respiratory Diseases.

Vincent Brooks Day & Son Lith. London W.C.

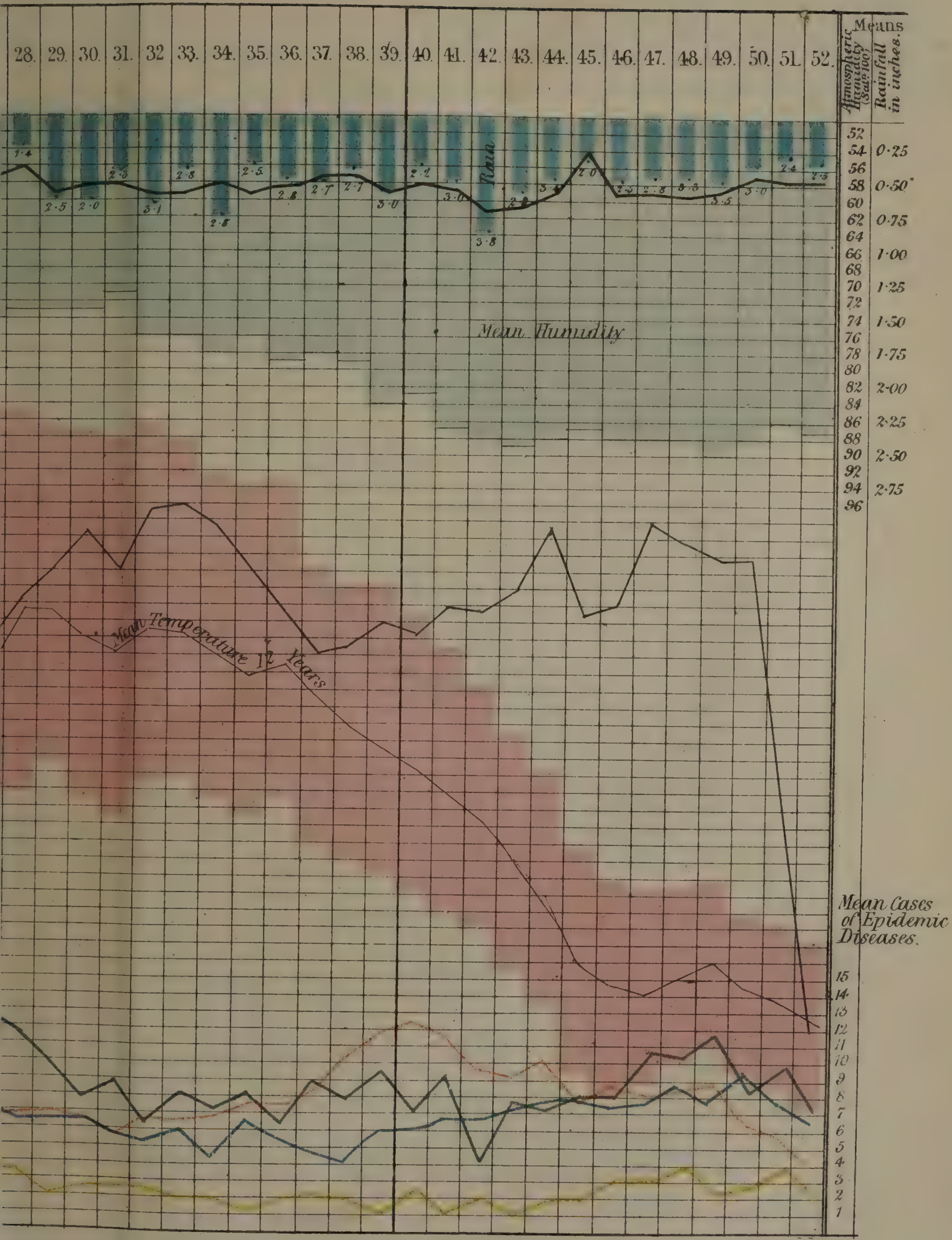
SUMMARY



Measles .... Scarlatina

= 12 YEARS.

Nº 26.



——Small pox ——Hooping Cough

Vincent Brooks, Day & Son, Lith. London W.C.

TABLE V.—*continued.*

SUMMER QUARTERS.

Of greater Prevalence of Scarlatina. / Of less Prevalence of Scarlatina.

Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
		°		Inches.				°		Inches.	
1858 -	72	61·0	74	5·39	29	1857 -	33	63·3	77	5·73	30
1859 -	103	62·0	73	7·10	33	1860 -	67	56·3	85	9·12	52
1863 -	217	59·1	74	5·18	27	1861 -	84	60·4	78	4·20	43
1864 -	96	59·4	71	4·37	24	1862 -	62	60·2	81	5·75	33
1865 -	94	62·5	75	6·41	29	1866 -	69	58·7	80	7·93	45
1867 -	136	59·7	78	11·40	35						
1868 -	141	64·1	70	4·40	23						
Mean -	122	60·1	74	6·32	28	Mean -	63	59·6	80	6·54	41

AUTUMN QUARTERS.

Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
1859 -	221	43·0	87	7·18	48	1857 -	25	47·4	92	5·56	23
1861 -	116	46·4	88	7·23	35	1858 -	68	43·5	87	3·11	31
1862 -	135	45·6	89	7·04	40	1860 -	53	42·8	89	4·59	35
1863 -	165	47·3	86	4·48	34	1864 -	65	43·6	82	4·13	29
1867 -	222	43·1	87	4·52	37	1865 -	71	46·1	88	8·92	37
1868 -	99	45·8	87	8·61	48	1866 -	95	46·5	87	5·36	48
Mean -	159	45·2	87	6·51	40	Mean -	62	45·0	87	5·27	33

In 1861 - -	472 cases, or	20·2 per 1,000 of all cases.
„ 1862 - -	279 „	11·6 „ „
„ 1863 - -	481 „	18·0 „ „
„ 1864 - -	256 „	10·6 „ „
„ 1865 - -	528 „	22·5 „ „
„ 1866 - -	586 „	21·3 „ „
„ 1867 - -	270 „	9·8 „ „
„ 1868 - -	595 „	18·1 „ „

There is no indication here of a cyclical recurrence of the disease such as was noted in respect of measles and scarlatina.

Diagram 26 shows the line of the distribution of hooping cough on the whole through the several seasons of the year. It resembles the line of measles in presenting two waves—a larger one culminating in the month of June, and a smaller one in the month of December. There are, however, between the two waves these differences, viz., 1st, that although they correspond in this respect, the waves of hooping cough seem to anticipate a little those of measles; and 2nd, that the waves are less pronounced, this being due to a more uniform distribution of the disease than is observed with measles.

The following represents the mean distribution of hooping cough through the several seasons of the year, as per 100 cases:—

In January - - -	8·4	Winter quarter, 25·6 cases.
„ February - - -	8·9	
„ March - - -	8·3	
„ April - - -	9·2	Spring quarter, 28·7 „
„ May - - -	9·3	
„ June - - -	10·2	
„ July - - -	7·6	Summer quarter, 20·0 „
„ August - - -	6·1	
„ September - -	6·3	
„ October - - -	7·6	Autumn quarter, 25·7 „
„ November - -	8·8	
„ December - -	9·3	
	100·0	1·00

The autumn and winter quarters appear to be alike in respect of the prevalence of hooping cough. The spring quarter is that in which I have observed that the disease prevails most, and the summer that in which it prevails least. The largest proportion of cases was observed to occur in the whole in the month of June, and the smallest in the months of August and September. The short period of time which elapses between the period of greatest and least prevalence is remarkable, the decline of the disease as summer comes on being very sudden.

The following represents the average meteorological conditions of the weeks about the period of the spring rise and subsequent sudden fall, and of the autumnal rise. I assume about a week as the period of incubation; probably it is something less than this, but it is not likely that medical aid would be sought until the disease was tolerably pronounced. I allow a week, then, in the table as a fair correction. I begin from the twelfth week of the year, thus to correspond with the last week of the winter quarter.

—	Average of new Cases, One Week later.	Mean Temperature.	Mean daily Range of Temperature.	Mean Humidity.	Mean Rainfall.	Rainy Days, 12 Years.
		°	°		Inches.	
12th week	8·0	40·9	15·0	81	0·41	33
13th " -	7·7	45·4	15·8	81	0·38	45
14th " -	6·6	46·6	17·4	82	0·38	34
15th " -	*8·2*	*46·6*	*17·4*	*81*	*0·44*	*40*
16th " -	9·6	48·2	20·3	75	0·14	19
17th " -	8·1	49·1	18·9	79	0·50	32
18th " -	8·3	49·2	19·2	74	0·22	23
19th " -	8·5	52·9	21·3	76	0 67	35
20th " -	7·8	53·7	19·6	78	0·53	32
21st " -	7·7	54·8	22·2	74	0·44	20
22nd " -	*9·5*	*57·8*	*21·1*	*76*	*0·82*	*33*
23rd " -	9·3	58·5	20·5	78	0·63	32
24th " -	9·4	58·8	21·8	74	0·35	26
25th " -	*8·6*	*60·2*	*22·0*	*75*	*0·47*	*32*
26th " -	7·2	60·4	20·7	74	0·48	32
27th " -	6·5	59 9	21·5	74	0·40	29
28th " -	6·5	63·6	23·7	73	0·23	17
29th " -	6·5	63·5	20·2	73	0·59	30
30th " -	5·6	62·0	21·4	73	0·63	25
31st " -	5·3	61·1	22·4	71	0·39	28
32nd " -	6·0	62·4	21·2	76	0·65	38
33rd " -	4·3	62·2	20·0	76	0·40	34
34th " -	6·8	60·8	19·3	78	0·74	34
35th " -	5·9	59·8	19·9	76	0·38	31
36th " -	4·8	60·3	18·9	79	0·48	34
37th " -	4·2	58·7	16·3	78	0·50	33
38th " -	*6·0*	*56·7*	*16·2*	*79*	*0·40*	*33*
39th " -	6·2	55·5	17·1	84	0·55	37
40th " -	6·8	54·5	16·2	83	0·37	27
41st " -	6·7	52·5	15·1	87	0·50	37
42nd " -	6·9	51·2	14·3	88	0·87	46
43rd " -	7·6	48·8	14·1	89	0·54	35
44th " -	8·0	46·7	14·8	88	0·47	41

From which it appears that, 1st. The spread of hooping cough is promoted by a mean temperature above 46°, and especially by a temperature between 57° and 60°. 2d. That a mean temperature above 60° is very unfavourable to the disease, and distinctly promotive of its decline when epidemic. 3d. That a mean temperature below 40° is also less favourable than one between 40° and 46°, but more favourable than a mean temperature above 60°. I have had some reason to suspect that a high barometric pressure is favourable to the occurrence of the convulsive affections of children, but there is no connexion traceable between this and the extension of hooping cough.

Table VI. shows for each quarter the more important meteorological conditions of the seasons in which hooping cough was more or less prevalent. From this it appears, 1. That in all seasons of the year, with the exception of autumn, the extension of hooping cough is promoted by a comparatively warm and dry atmosphere; in the autumn a warm and moist season appears to be most favourable to it. 2. In the spring and summer the unfavourable influence of atmospheric moisture and much rain is especially obvious. Great atmospheric dryness and little rainfall appear capable of counteracting to some extent the operation of a temperature above 60°, as in the summer of 1868. (See Table VI., pp. 70, 71.)

TABLE VI.

WINTER QUARTERS.

Of greater Prevalence of Hooping Cough.						Of less Prevalence of Hooping Cough.					
Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
		°		Inches.				°		Inches.	
1858	95	37·9	81	3·41	20	1857	41	36·3	85	3·79	35
1859	123	43·3	83	2·55	33	1860	40	38·9	82	3·80	52
1861	150	39·7	89	4·96	40	1862	56	40·6	86	5·73	43
1864	106	38·2	82	4·27	37	1863	83	42·5	83	4·08	35
1865	98	36·6	82	5·94	45	1867	92	38·5	83	6·29	51
1866	184	41·2	83	9·55	51	1868	97	41·1	82	6·52	46
Mean -	126	39·9	83	5·11	37	Mean -	68	39·6	84	5·03	43

SPRING QUARTERS.

Of greater Prevalence of Hooping Cough.						Of less Prevalence of Hooping Cough.					
Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
1858	125	54·7	72	5·07	30	1857	61	54·3	76	4·06	31
1861	158	51·6	81	4·73	30	1859	55	54·2	77	6·40	29
1865	154	56·3	72	7·24	24	1860	45	50·5	80	10·36	49
1866	193	52·9	75	8·00	35	1862	64	53·1	82	7·61	46
1868	248	55·1	74	4·22	21	1863	90	52·6	77	5·99	34
						1864	49	53·5	73	3·48	22
						1867	76	54·3	77	6·27	39
Mean -	175	54·1	75	5·85	27	Mean -	62	53·2	78	6·31	35

TABLE VI.—*continued.*

SUMMER QUARTERS.

Of greater Prevalence of Hooping Cough.						Of less Prevalence of Hooping Cough.					
Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
		°		Inches.				°		Inches.	
1858	58	61·0	74	5·39	29	1857	46	63·3	77	5·73	30
1861	115	60·4	78	4·20	43	1859	27	62·8	73	7·10	33
1863	142	59·1	74	5·18	27	1860	51	56·3	85	9·12	52
1865	137	62·5	75	6·41	29	1862	59	60·2	81	5·75	33
1866	103	58·7	80	7·93	45	1864	52	59·4	71	4·37	24
1868	89	64·1	70	4·40	23	1867	34	59·7	78	11·40	35
Mean -	107	61·0	75	5·58	32	Mean -	44	60·3	78	7·24	34

AUTUMN QUARTERS.

Of greater Prevalence of Hooping Cough.						Of less Prevalence of Hooping Cough.					
Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
1857	70	47·4	92	5·56	23	1859	54	43·0	87	7·18	48
1858	94	43·5	87	3·11	31	1861	49	46·4	88	7·23	35
1860	128	42·8	89	4·59	35	1864	49	43·6	82	4·13	29
1862	100	45·6	89	7·04	40	1867	68	43·1	87	4·52	37
1863	166	47·3	86	4·48	34						
1865	139	46·1	88	8·92	46						
1866	106	46·5	87	5·36	41						
1868	161	45·8	87	8·61	48						
Mean -	120	45·6	88	5·95	37	Mean -	44	44·0	86	5·76	37

Small Pox.

The 1,977 cases of small pox were distributed through the 12 years thus :—

In 1857	- 28	or	2·1	per 1,000 of all cases.
„ 1858	- 42	„	3·0	„ „
„ 1859	- 65	„	4·3	„ „
„ 1860	- 138	„	6·3	„ „
„ 1861	- 27	„	1·1	„ „
„ 1862	- 76	„	3·1	„ „
„ 1863	- 488	„	18·2	„ „
„ 1864	- 89	„	3·7	„ „
„ 1865	- 209	„	8·9	„ „
„ 1866	- 318	„	11·5	„ „
„ 1867	- 329	„	12·0	„ „
„ 1868	- 168	„	5·1	„ „

We have to note here a gradual increase of small pox year by year from 1857 to 1860, when it exhibited an approach to epidemic prevalence; then a sudden reduction in the next year, 1861, an increase in 1862, and the grand epidemic outburst of 1863. Again, in the year after the epidemic, in 1864, a diminution of small pox about proportional to what took place after 1860. Since 1864 small pox has been increasing in prevalence year by year until 1868, when in the middle of August it almost abruptly died away from among our population. From the second week in August until the second week in November only three cases, at long intervals, were recorded in the books to which I had access. A prolonged freedom from small pox such as this had not occurred in Islington since the middle of 1862. I may say here, by way of anticipation, that in no week of all the 11 years prior to 1868 did the mean temperature of any week exceed 71°, and that temperature only was attained in the 28th week of 1859; nor in any week prior to 1868 did the mean of the highest day temperature reach above 86°, and that was in the same week. In the four weeks of July 1859 the means of the maximum temperatures were 81·4°, 86·5°, 82·6°, and 79·0°. Nothing approaching so prolonged a high temperature in the daytime occurred again until last year. In the second week of July 1868, the mean of the maximum temperatures of the week was 79·8°; in the third, 86·0°; in the fourth, 84·4°; in the first week of August, 81·7°; and in the second, 83·6°. The mean temperature of the third week of July was 70·7°; of the fourth, 69·2; of the first week of August, 67·6°; and of the second, 69·8°.

Whatever, then, the causes may have been which for so many years past have fostered small pox, the cause of the disappearance of the disease in August last is scarcely possible to be overlooked. The efforts made since 1863 to render the vaccination of our population more complete and perfect have probably saved us, during 1866 and 1867, from an epidemic more serious even than that of 1863, which itself was three times more serious than that of 1860; but it is clear that the cessation of the plague has been the result of climatic conditions.

Diagram 26 shows the seasonal line of small pox as it has pursued its course on the average of the 12 years. Small pox, like scarlatina, forms but one wave in the course of the year. Its prevalence in the several months and quarters may be represented thus per 100 cases :—

In January -	- 8·7	Winter quarter, 27·1 cases.
„ February -	- 8·0	
„ March -	- 10·4	
„ April -	- 11·8	Spring quarter, 35·8 „
„ May -	- 14·3	
„ June -	- 9·7	
„ July -	- 7·2	Summer quarter, 17·9 „
„ August -	- 6·1	
„ September -	- 4·6	
„ October -	- 4·6	Autumn quarter, 19·2 „
„ November -	- 6·7	
„ December -	- 7·9	
	100·0	1·00

The rule has been for small pox to prevail least in the summer, to increase through the autumn and winter, and to prevail most in the spring of the year. The smallest number of cases on the whole was observed in the months of September and October; the wave rose gradually through the succeeding months (with a slight check in February), to attain its highest point in the month of May. From this point it sank rapidly through July and August, to attain its lowest point again in September. Small pox is therefore clearly a disease the extension of which is promoted by cold weather and checked by hot weather.

In any consideration of its association with conditions of weather an allowance of about a fortnight must be made for the incubation of the disease.

On the average of the 12 years we may regard the disease at its lowest point in the month of October, and the commencing increase to have taken place about the first week in November. The meteorological conditions on the mean of the 12 years about this time were as follows:—

—	Average of new Cases Two Weeks later.	Mean Temperature.	Mean daily Range of Temperature.	Mean Humidity.	Mean Rainfall.	Rainy Days, 12 Years.
		°	°		Inches.	
39th week	1·2	55·5	17·1	84	0·55	37
40th „ -	1·9	54·5	16·2	83	0·37	27
41st „ -	1·2	52·5	15·1	87	0·50	37
42nd „ -	1·8	51·2	14·3	88	0·87	46
43rd „ -	2·0	48·8	14·1	89	0·54	35
44th „ -	3·1	46·7	14·8	88	0·47	41
45th „ -	3·1	43·0	13·1	87	0·30	24
46th „ -	3·9	41·6	12·7	88	0·49	30

Small pox, then, may be considered as beginning to extend when the temperature at the commencement of the autumn begins to fall to about 50°, after which the disease becomes more and more prevalent as the temperature continues to sink, and again as beginning to rise towards the spring of the year. On the average of years the largest number of cases was observed in the 21st week of the year, immediately after which, in the 22d week, the number of cases fell remarkably. The

APPENDIX.

No. 3.
On the Results of an Analysis of Records of Sickness, &c., by Dr. Ballard.

following are the means of the meteorological conditions of the several weeks about this time :—

—	Average of new Cases Two Weeks later.	Mean Temperature.	Mean daily Range of Temperature.	Mean Humidity.	Mean Rainfall.	Rainy Days, 12 Years.
		°	°		Inches.	
17th week	4·6	49·1	18·9	79	0·50	32
18th „ -	5·0	49·2	19·2	74	0·22	23
19th „ -	6·5	52·9	21·3	76	*0·67*	35
20th „ -	3·9	53·7	19·6	78	0·53	32
21st „ -	3·6	54·8	22·2	74	0·44	20
22nd „ -	3·7	57·8	21·1	76	0·82	33
23rd „ -	3·4	58·5	20·5	78	0·63	32
24th „ -	3·6	58·8	21·8	74	0·35	26
25th „ -	3·2	60·2	22·0	75	0·47	32
26th „ -	3·2	60·4	20·7	74	0·48	32
27th „ -	2·0	59·9	21·5	74	0·40	29

Reading this with the preceding table, it appears that the mean temperature of about 52° is that which marks off the conditions favourable or unfavourable to the extension of small pox. A temperature below this promotes its spread, and a temperature above it tends to check its spread. It is clear, however, that this observation can only apply to the country in which it has been made, or to one presenting similar climatic conditions.

Table VII. shows the more important meteorological conditions which were existent in the several quarters in which small pox was more or less prevalent. (See Table VII., pp. 75, 76.) From which it appears :—

1. That with the exception of the spring and summer quarters, in the latter of which excessive heat is apt to check the spread of the disease, small pox is promoted by a comparatively warm season.
2. That in all seasons of the year comparative atmospheric dryness is more conducive to the spread of small pox than comparative humidity of the atmosphere.
3. That in every season except the autumn, there was on the whole a greater rainfall in the years of greater prevalence of small pox than in those of its lesser prevalence.

I may add further, that making the fortnight's allowance for incubation, great rises or falls of temperature appear to promote the extension of small pox in seasons when it prevails. In this it resembles measles.

The alleged connexion between epidemics of small pox and measles may be studied upon the diagrams.

1. As regards the slighter small pox outbreak of 1860, it is observable that although 1859 was not a year on which an epidemic of measles was due, yet, for a non-epidemic year, the disease was unusually prevalent during the three first quarters; it subsided during the autumn, and small pox broke out in the first month of 1860. As small pox subsided in May and June, measles again became severely epidemic.

2. In 1862 a heavy epidemic of measles occurred, the principal violence of the outbreak being expended upon the months of June and July. It subsided through August and September. In November the grand epidemic of small pox commenced, the disease spreading extensively in the month of December. In November and December measles became concurrently active. It subsided, however, as small pox gained

TABLE VII.

Winter Quarters.

Of greater Prevalence of Small Pox.						Of less Prevalence of Small Pox.					
Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfal.	Rainy Days.
		°		Inches.				°		Inches.	
1860	58	38·9	82	3·80	52	1857	5	36·3	85	3·79	35
1863	88	42·5	83	4·08	35	1858	13	37·9	81	3·41	20
1866	66	41·2	83	9·55	51	1859	16	43·3	83	2·55	33
1867	121	38·5	83	6·29	51	1861	32	39·7	89	4·96	40
1868	65	41·1	82	6·52	46	1862	3	40·6	86	5·73	43
						1864	22	38·2	82	4·27	37
						1865	45	36·6	82	5·94	45
Mean -	79	40·4	83	6·04	47	Mean -	19	38·9	84	4·37	36

Spring Quarters.

Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfal.	Rainy Days.
1860	37	50·5	80	10·36	49	1857	13	54·3	76	4·06	31
1863	291	52·6	77	5·99	34	1858	3	54·7	72	5·07	30
1865	62	56·3	72	7·24	24	1859	14	54·2	77	6·40	29
1866	74	52·9	75	8·00	35	1861	10	51·6	81	4·73	30
1867	102	54·3	77	6·27	39	1862	2	53·1	82	7·61	46
1868	68	55·1	74	4·22	21	1864	23	53·5	73	3·48	22
Mean -	105	53·6	76	7·01	32	Mean -	10	53·6	77	5·22	31

TABLE VII.—*continued.*

SUMMER QUARTERS.

Of greater Prevalence of Small Pox. | Of less Prevalence of Small Pox.

Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.	Years.	New Cases.	Mean Temperature.	Mean Humidity.	Total Rainfall.	Rainy Days.
		°		Inches.				°		Inches.	
1858	22	61·0	74	5·39	29	1857	1	63·3	77	5·73	30
1863	73	59·1	74	5·18	27	1859	13	62·8	73	7·10	33
1865	77	62·5	75	6·41	29	1860	12	56·3	85	9·12	52
1866	66	58·7	80	7·93	45	1861	2	60·4	78	4·20	43
1867	36	59·7	78	11·40	35	1862	7	60·2	81	5·75	33
						1864	19	59·4	71	4·37	24
						1868	20	64·1	70	4·40	23
Mean -	54	60·3	76	7·26	33	Mean -	10	60·9	77	5·81	34
					AUTUMN QUARTERS.						
1862	64	45·6	89	7·07	40	1857	4	47·4	92	5·56	23
1863	36	47·3	86	4·48	34	1858	7	43·5	87	3·11	31
1866	112	46·5	87	5·36	41	1859	13	43·0	87	7·18	48
1867	70	43·1	87	4·52		1860	12	42·8	89	4·59	35
						1861	5	46·4	88	7·23	35
						1864	25	43·6	82	4·13	29
						1865	25	46·1	88	8·92	46
						1868	15	45·8	87	8·61	48
Mean -	70	45·7	87	5·35	38	Mean -	13	44·8	88	6·16	36

strength during the early months of 1863. The chief violence of small pox in this year was expended upon the months of May and June, during which the ordinary spring increase of measles was observed. The end of 1863 and beginning of 1864 witnessed the reduction of small pox to a small number of cases, and in February measles again broke out, the commencement of a severe spring epidemic.

3. The slighter small pox epidemic of 1867 was again preceded by a heavy epidemic of measles in 1866, and its subsidence in 1868 by another heavy epidemic, lasting from May till the end of the year.

I feel that in this paper I have only skimmed the surface of a very interesting and important investigation, but perhaps it will be considered that the inferences drawn are as much as the records at my disposal suffice for. Probably a deeper study of the diagrams may suggest others; it does so to myself. The area from which the observed facts are drawn is comparatively a very limited one. I am conscious that my inferences can only therefore be regarded as provisional. I am aware of but very few places in which a regular registration of sickness among the poor has been attempted, and of no place where it has been steadily carried on for so many as 12 years, except in Islington. But I think I have indicated the important scientific results which would follow were a national registration of sickness established. I can testify from experience how small the amount of labour would be in effecting such a registration in each district of the kingdom. At the present time there exist everywhere abundant materials in the books kept by poor law medical officers, and at the various public institutions for the relief of sickness, but they are unused because it is nobody's business to collect them together. Were this done it would be possible to distinguish between the liability of different districts to diseases of certain kinds, and the difference in fatality which attends them in different places. This is a matter of no small moment, since the causes which occasion greater or less liability to suffer from a malady may be very different from those which render attacks more or less fatal. Moreover, the laws which govern the outbreak and spread of epidemic maladies might be clearly brought out, and perhaps it may not be too much to anticipate that in the progress of years facts enough might be collected on which to base a prognostication of disease.

The diagrams will now explain themselves. All that is necessary to add is that the small figures below each weekly rainfall signify the number of days on which rain fell in appreciable quantity.

APPENDIX.

No. 4.
On the Quantity, &c. of Venereal in London Institutions, by Mr. W. W. Wagstaffe.

No. 4.—REPORT, by Mr. WILLIAM W. WAGSTAFFE, on the QUANTITY and KINDS of VENEREAL DISEASE under TREATMENT at certain CHARITABLE INSTITUTIONS in LONDON.

Venereal diseases: division of.

IN the following report the term (A) *syphilis* has been applied to (1) the *infecting chancre* and its results, dividing these latter into (2) *constitutional* and (3) *hereditary*. The non-infecting or *soft chancre* (B) as not producing any necessary effects upon the health of the individuals or their children, but being a mere local disease, has been separated from the other venereal affections; and (C) *gonorrhœa* as being a disease distinct from the others, and of more or less special character, has been placed by itself. The term "*Venereal*" has been used to embrace all the above affections, syphilitic and non-syphilitic, which are traceable to contagion. Cases of doubtful character have been excluded from the accompanying tables, but they were not in sufficient number to materially influence the results.

Doubtful cases excluded.

Line of inquiry.

In order to obtain a fair statement of the proportion of cases of venereal disease among the London sick poor, I have, in accordance with instructions, visited one or more of each of the different kinds of institutions which minister to the relief of such persons; general hospitals, special hospitals, dispensaries, and workhouse infirmaries. From the more important of these institutions I have, with the willing permission of the authorities, obtained the returns personally, and am responsible for the diagnosis of the venereal disease in the cases upon which the tables are founded; and in other instances, where I was myself unable to attend, returns have been promptly supplied by the authorities or by trustworthy observers attached to the institution.

In regard to the cases included in this report, it may be stated that only those have been entered as venereal, where the disease for the relief of which the applicant presented himself was due directly or indirectly to some form of venereal affection, and no entry has been made of those who at some previous time in their lives have had one or other kind of such disease. In fact, it would be next to impossible to arrive at the truth if the latter line of inquiry had been taken.

Returns distinguished into departments,

It has been thought better to keep separate the returns for disease among out-patients from those referring to the in-patients of the different institutions, as the class of patients differs materially in the two cases; and also, since the returns which have been previously published on this subject have referred to special departments, to give the full statistics of the different departments into which the out-patient practice is divided.*

and according to sex and age.

It has also been felt desirable, in order to obtain a correct notion of the proportion of each sex affected with venereal disease, to distinguish males, females, and children as far as possible. This, however, was proved to be a difficult matter, for in none of the hospitals or institutions visited is this distinction ordinarily made. In the majority the returns are given under the two headings of "male" and "female," and the children in some cases are entered according to their sex, and in others are numbered with the women. In some institutions there is not even

* The tables printed in this report are summaries of more detailed tables also presented.

this distinction made, and a return is made in mass of the number of patients seen, regardless of their age or sex. The limit of age for "children" for the purpose of the inquiry has been assumed at about 14, or rather puberty, as (although in two instances acquired venereal disease was seen at the respective ages of six and ten, one from rape) it was considered that the age of puberty best marks the time below which the direct acquisition of any venereal affection is improbable.

In making these inquiries I have in the case of out-patients taken the proportion of venereal disease among the whole number of patients presenting themselves during a definite time, one week at the large general hospitals, and two or three days at the dispensaries, and have as carefully as possible avoided counting any patients, whether venereal or non-venereal, a second time, when they attended more than once during the time that institution was under observation. In regard to in-patients, I have followed my instructions in taking the proportion of venereal among them on single days only.

It seems to be the general opinion among the medical officers that the amount of venereal disease (especially among in-patients) is not so large at the present season of the year (August) as during the winter months, and the explanation given is that during the summer, and especially at the present time, men and women do not care to give up the time necessary for treatment in or out of doors, when the plentifulness of harvest and other work gives them the chance of earning good wages. This reason, however, would account for a diminution in the total number of patients, as well as in those affected by the particular class of diseases in question, so that the ratio of the one class of total sickness might be the same as usual, except in one respect, viz., that a much larger proportion of men would probably be drawn off by the summer full work, and as the per-centage of venereal is much higher among them than among women attending as patients, in this manner the total proportion of venereal disease may be somewhat lessened during the summer season among such patients.

Institutions under observation.

Returns have been obtained from among out-patients at the following institutions :— St. Bartholomew's Hospital, St. Thomas's Hospital, St. George's Hospital, for one week each ; Royal Free Hospital, for four days ; Western General Dispensary, for two days ; Finsbury Dispensary, for three days ; Farringdon Dispensary, for three days ; Surrey Dispensary, for 2 days ; Stanhope Street Dispensary, for two days.

And from among in-patients at the following :—St. George's Hospital, London Hospital, Royal Free Hospital, Female Lock Hospital, Male Lock Hospital, Lambeth Workhouse Infirmary, St. Pancras Workhouse Infirmary. The returns from these, as before mentioned, have reference to the patients actually under treatment on one single day in each institution.

OUT-PATIENTS : (1) OF GENERAL HOSPITALS.

Out-patients. General hospitals.—Deficiency of reliable records.

Although not within the immediate objects of this inquiry, it cannot be out of place to give prominent notice here to the deficiency of reliable records of the out-patient practice at all the public medical institutions visited.

For the purpose of clinical instruction such records would be most valuable, and in fact are almost essential to that form of teaching, and in inquiries of the nature of the present one they would also be of the utmost value. For either use, it is of course necessary that their correctness should be guaranteed by proper supervision. At the present

APPENDIX.
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time none even of the general hospitals which were visited possessed the means of showing, with any approach to accuracy, the proportion of any kind of disease treated among its out patients. A rough entry-book was certainly sometimes kept, but the entries in this were, in the majority of cases, made by junior students, or else by non-medical officials, and in neither case was there any attempt at exactness. There appeared to be no one whose duty it was to overlook these records, or to compile any results from them.

For the following out-patient statistics, all the departments into which that practice is divided have been included; but it has seemed advisable, in recording totals, not to take into consideration the cases of primary accident, *i.e.*, those applying shortly after an accident has happened, as such patients are not of a class fairly comparable with the rest of hospital out-patients. The totals on the Out-patient Tables, relate, therefore, to patients suffering more or less directly from what may be termed "disease," in contradistinction to accident.

Tabulation of returns.

Six tables (I., Ia., Ib., II., IIa., III.) have been prepared from the results obtained from the out-patient practice of general hospitals and dispensaries. Of these, tables I., Ia., Ib., refer to general hospitals only; tables II., IIa. to dispensaries; and table III. combines the results obtained from the inspection of the total out-patients (9,363), seen at both classes of institutions. The different departments of out-patient practice at general hospitals, which have, for reasons before stated, been kept distinct, are as follows:—1. Surgical out-patients, under the care of the assistant-surgeon; 2, surgical casualties; 3, ophthalmic patients; 4, medical out-patients under the care of the assistant physician; 5, medical casualties; 6, special department for diseases of women and children; and 7, department for skin diseases. The sexes have been distinguished, and children separated from women, where such a course has been found possible.

Except where otherwise stated, the returns have been obtained by myself.

Sources from whence returns obtained.

The following are the points which it appears necessary to note concerning the specialities of the out-patient practice at each hospital visited; and here I desire to record the names of the gentlemen to whom I am indebted for assistance in each department.

ST. BARTHOLOMEW'S.—Five departments formed the subject of inquiry at this hospital, and I have to acknowledge with pleasure the readiness with which all the officers of the institution assisted me by giving information, and by putting their patients at my disposal for examination:—1, the surgical out-patients' department, under the care of the assistant-surgeon, and including the ophthalmic and aural practice; 2, the surgical casualty department. The patients here were very numerous, and were carefully tabulated by the house surgeon; 3, the medical out-patients were noted by the assistant physicians in attendance (Drs. Southey, Church, and Gee); 4, the medical casualties; and 5, the department for diseases of women and children included no cases of venereal disease, as such are at once transferred to the surgical authorities.

ST. THOMAS'S HOSPITAL.—Seven departments are recognized here among the out-patients. 1. The surgical out-patients under the care of the assistant-surgeons. 2. The surgical casualties under the care of the house surgeons and dressers in which the returns were rendered by the former. 3. The ophthalmic out-patients. 4. The medical out-patients, for the accounts of which I am indebted to Dr. Clapton, the assistant physician. 5. The medical casualties seen by the resident medical officer or his assistant. 6. The department for skin diseases, the returns from which are furnished by Dr. Bristowe. 7. The obstetric special children's department under the care of Dr. Barnes and Dr. Gervis, who supplied the returns for this department.

TABLE I.—OUT-PATIENTS of General Hospitals.—TOTAL NUMBERS.*

Departments.	Surgical Out-patients.			Surgical Casualty.			Ophthalmic.			Medical Out-patient.			Medical Casualty.			Special Women and Children.		Skin.			Total according to Sex.			Grand Totals.
	M.	F.	CH.	M.	F.	CH.	M.	F.	CH.	M.	F.	CH.	M.	F.	CH.	F.	CH.	M.	F.	CH.	M.	F.	CH.	
No. of Out-patients	285	316	74	314	218†		—	—	—	127	268†		670	1,219†		120†		—	—	—	1,396	2,141	74	3,611
ST. BARTHOLOMEW'S:																								
Gonorrhœa, &c.	29	16	0	73	20					0	0		0	0		0					102	36	0	138
Soft chancre	13	7	0	9	0					0	0		0	0		0					22	7	0	29
Syphilis acquired	66	27	0	21	4					8	6		0	0		0					87	31	0	118
Do. hereditary	0	0	8	0	1					0	0		0	0		0					0	0	9	9
Venereal	108	50	8	103	25		—	—	—	8	6		0	0		0		—	—	—	211	74	9	294
No. of out-patients	160	195	139	188	261	177	28	74†		168	171		27	77	24	278	67	20	24	23	591	1,080	430	2,101
ST. THOMAS'S:																								
Gonorrhœa, &c.	31	2	0	23	3	0	1	0		0	0		0	0	0	0	0	0	0	0	55	5	0	60
Soft chancre	4	1	0	3	2	0	0	0		0	0		0	0	0	1	0	0	0	0	7	4	0	11
Syphilis acquired	25	22	0	3	2	0	4	5		2	1		0	0	0	3	0	2	0	0	36	33	0	69
Do. hereditary	0	0	2	0	0	0	1	0		0	1		0	0	0	3	2	0	0	0	1	4	4	9
Venereal	61	25	2	29	7	0	6	5		2	2		0	0	0	7	2	2	0	0	99	46	4	149
No. of out-patients	142	187	80	0	0	0	17	39	21	147	280	71	0	0	0	31†		0	0	0	306	537	172	1,015
ST. GEORGE'S:																								
Gonorrhœa, &c.	18	2	0	—	—	—	0	0	0	1	0	0				0					19	2	0	21
Soft chancre	6	0	0	—	—	—	0	0	0	0	0	0				0					6	0	0	6
Syphilis acquired	15	15	0	—	—	—	0	1	0	1	2	0				0					26	18	0	44
Do. hereditary	0	0	2	—	—	—	0	0	1		0	0				0					0	0	3	3
Venereal	39	17	2	—	—	—	0	1	1	12	2	0	—	—	—	0		—	—	—	51	20	3	74
No. of out-patients	341	160	48	55	65	19	0	0	0	328	439	35	0	0	0	0	0	0	0	0	724	664	102	1,490
ROYAL FREE:																								
Gonorrhœa, &c.	99	8	0	0	0	0				4	2	0									103	10	0	113
Soft chancre	23	2	0	0	0	0				0	0	0									23	2	0	25
Syphilis acquired	43	27	0	0	0	0				25	19	0									68	46	0	114
Do. hereditary	0	0	3	0	0	0				0	0	1									0	0	4	4
Venereal	165	37	3	0	0	0	—	—	—	29	21	1	—	—	—	—	—	—	—	—	194	58	4	256

* The time of observation was a week in the case of St. Bartholomew's, St. Thomas's, and St. George's respectively, and four days at the Royal Free.
† In these cases women and children were not taken separately.
NOTE.—Where lines are drawn obliquely across the spaces the special department was not represented.

TABLE I a.

PER-CENTAGE SUMMARY of VENEREAL DISEASES occurring among OUT-PATIENTS at General Hospitals.

Departments.	Surgical Out-patients.			Total.	Surgical Casualties.			Total.	Ophthalmic.			Total.	Medical Out-patients.			Total.	Medical Casualties.			Total.	Special Women and Children.		Total.	Skin.			Total.	Total according to Sex.			Total.
	M.	F.	CH.		M.	F.	CH.		M.	F.	CH.		M.	F.	CH.		M.	F.	CH.		F.	CH.		M.	F.	CH.		M.	F.	CH.	
St. Bartholomew's	37·89	15·82	10·81	23·11	32·80	11·00	0	24·06	—	—	—	—	0·39	2·23	0	3·54	0	0	0	0	0	0	0	—	—	—	—	15·11	3·45	10·81	8·14
St. Thomas's -	37·50	12·82	1·43	17·61	15·42	2·68	0	5·78	17·85	6·75	(·98)	10·78	1·19	·58	0	1·18	0	0	0	0	1·43	2·98	2·60	10·0	0	0	2·9	16·57	3·88	·9	7·09
St. George's -	27·45	9·08	2·50	14·18	0	0	0	0	0	2·56	4·76	2·59	8·16	·71	0	2·81	—	—	—	—	0	0	0	—	—	—	—	16·29	3·88	1·17	7·22
Royal Free -	48·38	23·12	6·24	37·34	0	0	0	0	—	—	—	—	8·83	4·78	2·85	6·36	—	—	—	—	—	—	—	—	—	—	—	26·78	8·72	3·92	17·17

TABLE I b.

Particular forms of VENEREAL, per cent. of total PATIENTS irrespective of Age and Sex, under Treatment as OUT-PATIENTS at General Hospitals.

——	St. Bartholomew's.	St. Thomas's.	St. George's.	Royal Free.
Gonorrhœa or complications -	3·82	2·85	2·05	7·58
Soft chancre - - -	·80	·52	·58	1·67
Syphilis acquired - - } Do. hereditary - - }	3·51	3·71	4·59	7·92
Venereal in any form -	8·14	7·09	7·22	17·17

Appendix.

No. 4.
On the Quantity, &c. of Venereal in London Institutions, by Mr. W. W. Wagstaffe.

St. George's Hospital.—At this hospital five departments are recognized among the out-patients. 1. The surgical out-patients under the care of the assistant-surgeons. 2. The surgical casualties comprise only accidents and emergent cases, and are therefore not taken into consideration in the statistics. 3. For the return of medical cases I am indebted to the kindness of the assistant physicians (Drs. Dickinson and J. W. Ogle). 4. The women's special department under the care of Dr. J. Clarke, showed no cases of venereal. 5. The ophthalmic out-patients.

The proportion of venereal is rather less among the assistant surgeons' surgical out-patients than at either of the other two general hospitals, (14 per cent. against 17 and 23 per cent.,) and this is more marked among the males of this department, for it will be seen that at St. George's 27 per cent. of males are affected against 37 per cent. among the assistant-surgeons' out-patients at St. Bartholomew's and St. Thomas's.

Royal Free Hospital.—The surgical out-patient here comprised an unusually large number of venereal cases in comparison with other general hospitals. At this institution there seems to be a tendency to make a speciality of this class of diseases, owing partly to the original associations of the place,* and partly to the fact that the name and reputation of the hospital lead many to suppose no questions are asked and no trouble is necessary in order to obtain relief as an out-patient.

The per-centage of venereal among the surgical males here rises to nearly 50, or one out of every two seen, and for all sexes and ages in this department to 37·34, or more than one out of three; while the total per-centage for all sexes and departments among the out-patients reaches to over 17 per cent.

The notes of the cases occurring on the medical side were made by Dr. Keagey, late of St. Thomas's Hospital, who was present during the four days this institution was under observation and fully satisfied himself of the correctness of the details collected.

Among the surgical casualties no cases of venereal occurred.

Out-patients (2) of Dispensaries.

Dispensaries.

Returns were supplied from the following:—1. Western General Dispensary, Marylebone Road, by Mr. John Waller, the Resident Medical Officer, 2. Finsbury Dispensary, Woodbridge Street, by Mr. Lewis J. May, Resident Medical Officer. 3. Farringdon Dispensary, by the Medical Officers. 4. Surrey Dispensary, by Mr. F. W. Smith, House Surgeon. 5. The Public Dispensary, Stanhope Street, by Mr. H. Morris, M.B., House Surgeon.

Why proportion of venereal disease among these is small.

A much smaller proportion of venereal disease is to be noticed in these returns than in those from the general hospitals. The explanation, however, of this is apparent. In all the dispensaries, the production of a Governor's letter is necessary before a patient can be seen by the surgeon or physician, and a large number, if not the majority of the patients are connected by ties of dependence with the donors of the letter. Persons suffering from contracted venereal disease will hesitate to seek for a letter under these circumstances with the almost absolute certainty of being asked by the governor the nature of their malady, especially when hospitals are at hand offering treatment without fear of this disease becoming known elsewhere.

This reason bears upon all dispensaries, and in addition there is among most of them a rule, expressed or traditional, that primary venereal affections are not fit objects for the charity of the governors.

Hereditary syphilis.

The proportion of cases of hereditary syphilis at dispensaries may probably be looked upon as more correct for sick children generally,

* The hospital was founded ostensibly for the relief of the most destitute poor, who could not get letters of recommendation to the other hospitals; and of this class of persons prostitutes formed a notable proportion.

TABLE II.

OUT-PATIENTS of DISPENSARIES.

TOTAL NUMBERS.

—	Western General Dispensary. (2 Days.)				Finsbury Dispensary. (3 days.)				Farringdon Dispensary. (3 days.)				Surrey Dispensary. (2 days.)				Stanhope Street Dispensary. (2 days.)				Totals according to Sex.			
Number of Patients seen - -	M. 98	F. 164	CH. 78	Total. 340	M. 25	F. 127	CH. 69	Total. 221	M. 51	F. 113	CH. 28	Total. 192	M. 69	F. 227	CH. 24	Total. 320	M. 15	F, 41	CH. 8	Total. 64	M. 258	F. 672	CH. 207	Total. 1,137
Gonorrhœa or Complications -	2	0	0	2	0	0	0	0	6	1	0	7	1	0	0	1	3	0	0	3	12	1	0	13
Soft chancre - - - -	1	2	0	3	0	0	0	0	1	1	0	2	0	0	0	0	0	0	0	0	2	3	0	5
Syphilis, acquired - - -	2	3	0	5	0	2	0	2	3	3	0	6	0	1	0	1	0	1	0	1	5	10	0	15
Ditto, hereditary - - -	0	0	7	7	0	0	2	2	0	0	0	0	0	0	1	1	0	0	0	0	0	0	10	10
Venereal of all forms - -	5	5	7	17	0	2	2	4	10	5	0	15	1	1	1	3	3	1	0	4	19	14	10	43

TABLE II a.

PER-CENTAGES.

Proportion per cent. of																								
Gonorrhœa or Complications -	2·04	0	0	·59	0	0	0	0	11·76	·88	0	3·64	1·44	0	0	·31	20·0	0	0	4·70	4·65	·14	0	1·14
Soft chancre - - - -	1·02	1·22	0	·88	0	0	0	0	1·96	·88	0	1·04	0	0	0	0	0	0	0	0	0·77	·44	0	·44
Syphilis, acquired - - -	2·04	1·82	0	1·47	0	1·57	0	·91	5·88	2·65	0	3·12	0	·44	0	·31	0	2·43	0	1·56	1·93	1·48	0	1·32
Ditto, hereditary - - -	0	0	8·97	2·06	0	0	2·89	·91	0	0	0	0	0	0	4·16	·31	0	0	0	0	0	0	4·83	·88
Venereal of all kinds - -	5·10	3·04	8·97	5·00	0	1·57	2·89	1·82	19·60	4·41	0	7·80	1·44	·44	4·16	·94	20·0	2·43	0	6·26	7·36	2·08	4·83	3·78

here than at a large general hospital, where a comparatively larger number of acute cases is received, and where it is much more difficult, without the employment of special means, to separate accurately the number of children from the rest of the patients seen. It will be observed in the return that 4·83 per cent. of the sick children applied with disease traceable to syphilis in their parents.

SUMMARY OF OBSERVATIONS ON OUT-PATIENTS.

At hospitals the proportion of venereal disease is very different in different departments of out-patients.

From the preceding tables it is evident that in the three general hospitals (St. Bartholomew's, St. Thomas's, and St. George's), which represent most fairly the general hospitals of the Metropolis, a great difference exists in the several departments in regard of the prevalence of venereal disease. By far the greater proportion appears in the surgical practice (including surgical out-patients, surgical casualties, and ophthalmic out-patients) and a statement to the public of returns derived from such surgical out-patients alone would considerably exaggerate the prevalence of venereal generally among the sick poor of London. At St. Bartholomew's for instance, the proportion of venereal among surgical out-patients is over 23 per cent., whereas among the out-patients generally, excluding primary accidents it is just over 8 per cent. A similar difference is also observable at the Royal Free Hospital. The returns from the dispensaries do not satisfactorily separate the medical from the surgical practice, but the same proportionate difference would probably not be found, as there is not usually the same care in distinguishing between the two classes of cases.

Close agreement in the returns from the general hospitals.

Although much larger numbers of patients always attend on the early days of the week, I do not find that the proportion of venereal cases among them is appreciably different.

The three large general hospitals agree very closely as to their results as the following per-centage figures will show.

Disease.	St. Bartholomews.	St. George's.	St. Thomas's.	Royal Free.
Gonorhœa - -	3·82	2·05	2·85	7·58
Soft chancre - -	·80	·58	·52	1·67
Syphilis - - -	3·51	4·59	3·71	7·92
Venereal generally -	8·14	7·22	7·09	17·17

Compared with these the Royal Free Hospital presents a much larger per-centage, and the increase seems nearly equal in the three classes into which venereal disease is divided.

The return from dispensaries gives a total of gonorrhoea 1·14 ; soft chancre, ·43 ; syphilis, 2·19 ; giving a total per-centage of venereal, 3·78.

The total results of the foregoing returns from the out-patient departments of different institutions collectively are embodied in Table III., by which it will be seen that of 9,363 out-patients in all departments of all the charitable institutions visited, 8·71 per cent. were affected with venereal disease of some kind, and of these 3·68 were gonorrhœa, ·81 were soft chancre, 4·21 were syphilis.

TABLE III.

TOTAL VENEREAL among OUT-PATIENTS of HOSPITALS and DISPENSARIES reported upon.

—	Actual Numbers.				—	Per-centage Numbers.			
	Males.	Females.	Children.	Total.		Males.	Females.	Children.	All Ages and Sexes.
Number of Patients - -	3,282	5,097	984	9,363	Proportion per cent. of	100	100	100	100
Gonorrhœa or Complications	291	54	0	345	Gonorrhœa or Complications	8·86	1·06	0	3·68
Soft chancre - -	60	16	0	76	Soft chancre - -	1·82	·31	0	·81
Syphilis, acquired - -	222	139	0	361	Syphilis, acquired - -	6·76	2·73	0	3·85
Ditto, hereditary -	0	0	34	34	Ditto, hereditary -	0	0	3·45	·36
Venereal of all kinds -	573	209	34	816	Venereal of all kinds -	17·44	4·10	3·45	8·71

In-patients of General Hospitals and Workhouses.

In-patients.—Manner in which returns were taken.

The returns of in-patients affected with venereal diseases in different institutions are not sufficiently comprehensive to afford a basis for any general deductions. I have therefore simply given the results in the Tables IV. and IV a.—Table IV. showing the total numbers, and IV a. the proportions per cent., and have not attempted to combine them. A more extended inquiry would be necessary before a fair judgment of the proportion of venereal disease among the in-patients generally of London hospitals could be formed. The plan has been adopted of taking the actual number of patients in hospital on a particular day, noting the number of venereal cases found among them; so that the returns represent the proportion of venereal in hospital on a specified day.

Sources from whence obtained.

For the return from St. George's Hospital I am indebted to the surgical registrar, Mr. Wm. Leigh, and may state it is his impression that the proportion at the present time is rather below their average of such cases.

At the London Hospital the returns were made by the registrars (Mr. Tay and Dr. Woodman), and they too are of opinion that their present number of venereal cases is smaller than usual. St. Bartholomew's and Guy's Hospitals have furnished no returns. At the Royal Free Hospital, there is an even greater proportion of venereal cases among in-patients, as compared with other general hospitals than was noticed among the out-patients, but this is not surprising when of the only two female wards in the hospital one is exclusively devoted to venereal affections.

From the two workhouses of Lambeth and St. Pancras, I have with the permission of the authorities personally investigated the venereal cases among the inmates of the infirmaries, and the great difference in the results obtained requires some explanation. Lambeth shows a per-centage of 2·53 venereal cases in the infirmary, while in St. Pancras it amounts to 10·6. In the Lambeth Infirmary, however, the proportion of venereal to total diseases is due to the fact that a much larger proportion of cases of senile debility are lodged there than at St. Pancras; in fact, the excess in the actual number of inmates in Lambeth Workhouse Infirmary over those in St. Pancras is completely made up by patients suffering from old age rather than from any actual disease. In the former, the number of patients in the infirmary is 315 out of a total of 944 in the workhouse, while at St. Pancras (the old people being lodged elsewhere) only 132 out of 1,645 are infirmary patients. If the proportion of venereal cases to the whole number of inmates be taken, the results for the two workhouses would be found almost identical, being 0·84 per cent. for Lambeth, and 0·85 per cent. for St. Pancras.

Patients of Special Lock Hospitals.

Special hospitals.

In order to obtain further materials for determining the quality of prevalent venereal disease, I have applied for and obtained returns from the Female Lock Hospital and from the Male Lock Hospital through the kindness of their respective medical officers, Mr. F. J. Marshall and Mr. C. H. Lister.

Mr. Berkeley Hill has also forwarded me a report of the out-patients under his care, from the commencement of the present year to June 30th.

From these it would appear that the number of cases of gonorrhœa among in-patients at the special hospitals reported upon was proportionally much greater than any other forms of venereal. The out-patients have not been classed in Mr. Hill's returns in the same manner, but simply into syphilitic and non-syphilitic, and show a proportion 41·5 per cent. of the former against 58·5 per cent. of the latter. Tables setting out in detail the facts about the nature of the venereal diseases treated at these hospitals accompany this report.

TABLE IV.

IN-PATIENTS of General HOSPITALS and WORKHOUSES.

TOTAL NUMBERS.*

—	St. George's Hospital.				London Hospital.				Royal Free Hospital.				Lambeth Workhouse.				St. Pancras Workhouse.			
	M.	F.	CH.	Total.	M.	F.	CH.	Total.	M.	F.	CH.	Total.	M.	F.	CH.	Total.	M.	F.	CH.	Total.
No. of Patients under Treatment - -	160	148	0†	308	293	154	30	477	44	37	0	81	116	178	21	315‡	50	63	19	132§
Gonorrhœa and Complication - - -	1	1	0	2	1	1	0	2	0	6	0	6	0	0	0	0	1	2	0	3
Soft chancre - - - - -	0	1	0	1	0	0	0	0	0	3	0	3	0	0	0	0	3	4	0	7
Syphilis, acquired - - - - -	10	13	0	23	8	9	0	17	3	11	0	14	2	6	0	8	2	2	0	4
Ditto, hereditary - - - -	0	0	0	0	0	0	4	4	0	0	0	0	0	0	0	0	0	0	0	0
Venereal of all kinds - - -	11	15	0	26	9	10	4	23	3	20	0	23	2	6	0	8	6	8	0	14

TABLE IV a.

PER-CENTAGES.

	St. George's M.	St. George's F.	St. George's CH.	St. George's Total.	London M.	London F.	London CH.	London Total.	Royal Free M.	Royal Free F.	Royal Free CH.	Royal Free Total.	Lambeth M.	Lambeth F.	Lambeth CH.	Lambeth Total.	St. Pancras M.	St. Pancras F.	St. Pancras CH.	St. Pancras Total.
Proportion per cent. of Gonorrhœa and Complications - - -	·62	·67	0	·65	·34	·65	0	·42	0	16·21	0	7·40	0	0	0	0	2·0	3·17	0	2·27
Soft chancre - - - - -	0	·67	0	·32	0	0	0	0	0	8·10	0	3·70	0	0	0	0	6·0	6·34	0	5·30
Syphilis, acquired - - - - -	6·25	8·78	0	7·46	2·72	5·84	0	3·56	6·81	29·73	0	17·28	1·72	3·36	0	2·53	4·0	3·17	0	3·03
Ditto, hereditary - - - -	0	0	0	0	0	0	13·33	·84	0	0	0	0	0	0	0	0	0	0	0	0
Venereal of all kinds - - -	6·87	19·12	0	8·44	3·06	6·49	13·33	4·82	6·81	54·04	0	28·38	1·72	3·36	0	2·53	12·0	12·68	0	10 60

* NOTE.—These numbers represent the results of observations made on a single day in each institution.

† In the return from St. George's Hospital the children are not separated from females.

‡ NOTE.—The total number of inmates of Lambeth Workhouse, including Infirmary and all departments, was 944, and the proportion of venereal sick was therefore 0·84 per cent.

§ NOTE.—The total number of inmates of St. Pancras Workhouse, including Infirmary and all departments was 1,645, and the proportion of venereal sick was therefore 0·85 per cent.

TABLE V.

IN-PATIENTS of LOCK HOSPITALS.

	Female Lock.			Male Lock.			Total.	Proportion per cent.
	M.	F.	CH.	M.	F.	CH.		
Total number of patients -	0	123	0	15	0	0	138	0
Gonorrhœa or complications.	0	61	0	2	0	0	63	45·65
Soft chancre - -	0	28	0	7	0	0	35	25·36
Syphilis, acquired -	0	34	0	6	0	0	40	28·98
Ditto, hereditary -	0	0	0	0	0	0	0	0

OUT-PATIENTS OF LOCK HOSPITALS.

Under Treatment during six months at the Female Lock Hospital.		
Number of patients -	378	Proportion per cent.
Non-syphilitic - -	157	41·53
Syphilitic - -	221	58·47

GENERAL OBSERVATIONS.

The foregoing returns have reference to the amount and kinds of venereal disease observed during a certain time at various charitable institutions in London; and it may not be amiss in conclusion to give an approximate of these proportions among the total sick poor of the metropolis.

Definition of the term "sick poor."

Confining the term "sick poor" to such as receive medical relief gratuitously at public institutions, and at the hands of the poor law administrators, it will be necessary, in order to obtain an idea of their numbers, to take them as follows: (A) those relieved at general hospitals, (B) those relieved at dispensaries and special hospitals, and (C) those receiving parochial medical relief.

Estimation of total numbers of sick poor of the metropolis.

The calculation of the total numbers relieved by these different means can only be an approach to the truth, for in many instances no returns are published or kept; in others there is no attempt whatever at accuracy; while at many of the charitable institutions there is a tendency to greatly overstate the amount of real work done. From the actual returns where obtainable, and from other sources where no returns are made, it seems that the following will represent the total number of sick poor relieved during the year:

(A) At general hospitals, as shown by their returns	554,450
(B) At special hospitals and dispensaries, as shown by their returns - - - -	800,000
(C) By parish medical officers (calculated) -	180,000
Total - - - -	1,534,450

It appears further that those hospitals and dispensaries which have been the subject of this report minister to the relief of a very large proportion of the sick poor contained in classes (A) and (B)—as much,

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On the Quantity, &c. of Venereal in London Institutions, by Mr. W. W. Wagstaffe.

in fact, as 25 per cent., or one-fourth. But it will evidently be incorrect to give the proportion of venereal diseases which occur among these patients (A) and (B) as the proportion of venereal diseases among the total sick poor of the metropolis. It will be necessary to add 25 per cent. of the parochial sick (C) before fair deductions can be made. It would be a matter of considerable difficulty however to give the return of this class of cases (C) with accuracy; it would require greater time and labour than the results to be obtained would counterbalance. But I have computed it, I think not unfairly, by obtaining a return from each of the medical officers of one of the largest unions (Lambeth). From these it would seem that 0·33 per cent. of the population, or one in 300, receive relief from the parochial medical officers in an average week. Taking the population to be about 3,000,000, it will follow that about 9,900 are weekly under the hands of the parish medical officer, and one-fourth of this number, or 2,475, must be added to the corresponding fourth of hospital and dispensary patients included in this report. Venereal in these parish out-patients is not treated by the parish doctor, but is accounted for in various hospital returns.

A week's return of one-fourth of the sick poor of London, showing the proportion of venereal cases among them.

The following will therefore represent a weekly return of the number and proportion of venereal cases during about a week's observation of in-patients, out-patients, and parish cases among about one-fourth of the whole population of the metropolis :—

Class of Patients.	Total Number reported on.	Number of Venereal Cases.	Proportion of Venereal Cases per cent.
In-patients of hospitals, dispensaries, and workhouse infirmaries - -	1,313	94	7·16
Out-patients of hospitals and dispensaries	9,363	816	8·71
Parochial out-patients - - -	2,475	0	0
Totals - - -	13,151	910	6·92

So that 6·92 will probably represent the per-centage of the sick poor population affected with some form of venereal disease, syphilitic or non-syphilitic.

Proportion of syphilitic and non-syphilitic cases arranged according to sex.

If we inquire a little further, and distinguish the non-syphilitic from the syphilitic forms of disease, and separate men, women, and children into different groups, we may obtain the following results :—

———	Total.	Males.	Females.	Children.
Total number of patients reported on -	13,151	4,935	6,647	1,569
Of which there were suffering from				
(*a*) Non-syphilitic forms of venereal disease.	445	357	88	0
(*b*) Syphilitic - - - -	465	247	180	38
Totals - - -	910	604	268	38
Or expressed in per-centages :				
(*a*) Non-syphilitic - - -	3·38	7·23	1·32	0
(*b*) Syphilitic - - -	3·53	5·00	2·71	2·42
Total - - -	6·92	12·23	4·03	2·42

If this report be considered extensive enough (and it comprises about a week's observation of presumably one quarter of the sick poor of London) to warrant general deductions being made, it may be inferred that among the million and a half of poor population of the metropolis who receive medical relief for disease at hospitals, dispensaries, workhouses, and at the hands of the parochial medical officers during the year, nearly 7 per cent., or about 1 in 14, are affected with venereal disease of some kind. These numbers, it must be remembered, do not include midwifery cases.

The amount of true syphilis is slightly in excess of the non-infecting forms of venereal disease, but the contrary holds good when men are considered apart from women and children; for among this sex the percentage of non-syphilitic stands at 7·23 against 5·00 per cent. of syphilis. By far the larger proportion of venereal disease is to be noted among the males, the returns showing three times as much among them as among females. The proportion of hereditary syphilis among children cannot, I am afraid, be satisfactorily deduced from these tables, as no cases have been reported in the parochial returns. In order, however, to obtain some data for a rough estimate of the quantity of hereditary syphilis among the sick children of the class that would frequent hospitals, the published statistical returns of the Great Ormond Street Hospital have been examined, and it appears that of 118,590 children treated there as in and out patients during the last ten years, 1,786, or a proportion of nearly 1½ per cent., are recorded to have been syphilitic.

No. 5.—Further Report by Dr. Sanderson on the Inoculability and Development of Tubercle.

In my last report I expressed the opinion, in terms as definite as my observations seemed to justify, that the disease produced by tuberculous inoculation might be regarded as an overgrowth in the affected parts of those structural elements which they have in common with the pulp contained in the alveoli of the lymphatic glands. I had also found that the structural alterations in which the disease manifested itself were remarkably constant in their character and development—consisting of (1.) Induration and suppuration of the subcutaneous connective tissue at the point of insertion, attended with the formation of secondary nodules of induration of the same tissue in the immediate neighbourhood. (2.) Enlargement, induration, and caseous degeneration of the lymphatic glands in relation with the seat of primary infection. (3.) Appearance of nodules in the lungs, having to the naked eye the translucent aspect of grey tubercle, though differing therefrom in structure. (4.) Enlargement of the liver, consequent on interstitial growth of new material between the lobules. (5.) Hypertrophy of the spleen. (6.) Formation in various parts of the peritonæal surface of nodules, consisting of elements anatomically identical with those naturally to be found in the affected parts.

Summary of conclusions contained in last report.

As regards the conditions of infection, I had concluded from experiments that in rodent animals the tuberculous process may originate not merely by the inoculation of tubercle, but by any irritation of the requisite intensity applied to the subcutaneous tissue, and that any external injury, provided that the animal survives its immediate effects, is capable

of becoming the first link in a chain of pathological changes which cannot be distinguished from those produced by the insertion of tuberculous material. In correspondence with this inference, I had found that in almost every animal inoculated, suppuration had occurred at the point of insertion, a fact which seemed to indicate that, however specific might be the characters of the subsequent stages of the process, the characteristic phenomenon of common inflammation attended its origin. Had abscesses been found at the seat of inoculation in every case, I should have been compelled to believe that the formation of pus was essential. But it was not so, for in some of the animals there were no abscesses.

The facts from which I had concluded that tuberculosis may originate traumatically, although very limited in number, were of so positive a nature that I ventured to state that the results of tuberculous inoculation could no longer be regarded as necessarily dependent on any property or action possessed by the inoculated material in virtue of its having been taken from a tuberculous individual.* The truth of this inference has now been completely established by the experiments of two of the most competent observers, Dr. Wilson Fox, Professor of Clinical Medicine in University College,† and Dr. Cohnheim of Berlin. The following paragraph contains a summary of their results, which are the more valuable as they were arrived at altogether independently and without knowledge either of each other's inquiries or of mine.

Observations of Dr. Wilson Fox and Dr. Cohnheim as to the conditions of tuberculous infection.

From the tabular summary of Dr. Fox's experiments (117 in number), it appears that of 70 animals inoculated with various products derived from bodies of non-tuberculous patients, about half (34) became tuberculous. In addition, five animals were inoculated with putrid but originally healthy muscle, and four of them became in like manner tuberculous, as was found when they were killed at various periods from 84 to 122 days after inoculation. Of seven animals in which setons or other mechanical irritants were introduced under the skin, two became tuberculous.‡ This research, no less remarkable for the accuracy and completeness of the anatomical details than for the conclusiveness of the experiments, was followed only the other day by another in Berlin, which although of similar nature appears by internal evidence to have been conducted in entire ignorance that several of the questions investigated had already been completely settled in England. Drs. Cohnheim and Fränkel, for the purpose of obtaining an answer to the question, "Does artificial tubercle owe its origin to a specific virus?"§ introduced into the peritonæal cavities of guinea pigs portions of various tumours (carcinoma, sarcoma, condyloma, &c.), as well as of healthy but

* With reference to the traumatic origin of tuberculosis in the guinea-pig, another possibility claims consideration, namely, that of the influence of the air and of the organisms which it contains. It has not yet been proved that injuries, which are of such a nature that air is completely excluded from contact with the injured part, are capable of originating a tuberculous process. The following experimental results seem, indeed, to suggest that they may not be so. Setons steeped in carbolic acid were inserted in 10 guinea-pigs on the 24th of September 1868, each animal receiving two. At the same time extensive fractures of both scapulæ were produced in five others, care being taken not to injure the integument. No tuberculosis or other disease of internal organs has resulted in either case.

† "On the Artificial Production of Tubercle in the Lower Animals."—London: McMillan & Co., 1868.

‡ It is of importance to note that all these experiments were completed before the appearance of my last report.

§ Cohnheim and Fränkel. Untersuchungen über die Ueberträgbarkeit der Tuberculose auf Thiere. Virch. Archiv. Bd. xlv. 1868, p. 216.

partly decomposed tissue. Subsequently they employed in the same way a variety of insoluble inert substances, such as blotting paper, charpie, gutta percha, caoutchouc, vulcanite, &c. In those animals that survived the immediate effects of the injury, emaciation supervened sooner or later, and the animals eventually died with tuberculosis of the peritonæum, liver, spleen, lungs, and other organs, the morbid appearances corresponding in every respect with those described in my last report.

Perfect identity of artificial tuberculosis with miliary tuberculosis in man.

As regards the bearing of these facts on the general question of the nature and origin of tuberculosis, I concluded from my own observations that there is no structural distinction between the artificial disease and human tubercle, so long as the term is confined, as all accurate writers are now accustomed to confine it, to miliary tuberculosis; but I considered it necessary to maintain a reserve as to its relation with the many pathological processes which are spoken of as tuberculosis in the common language of practical medicine and surgery. In going so far the two distinguished pathologists already quoted have fully agreed with me. Dr. Fox says: "I múst confess that sceptical as everyone must "naturally at first feel on this subject, the cumulative force of the "evidence in favour of the tubercular nature of these growths appears "to me irresistible. We are either dealing with tubercle, or we have "before us a new and hitherto unknown constitutional disease of the "rodentia, consisting of growths which, in their naked eye appearances "and histological characters, correspond with all the essential features "of tubercle in man; which occur not only in the organs which are the "chosen seats of tubercle in man, but also in the same parts of those "organs; which have the same vital characters, and the same early degene-"rative cheesy changes, not suppuration nor acute softening, and with "no marked characters sufficient to distinguish them from tubercle."* Cohnheim says, "All the marks by which tubercle is characterized, as "such, are present; the agreement of the product of inoculation with "human miliary tubercle could not be more complete than it is, whether "regard be had to its extended distribution, and to the great variety of "organs affected, (peritonæum, pleura, lungs, liver, spleen, lymphatic "glands, and even the choroid,) or to its macroscopical and micro-"scopical characters."

In the work done during the past year my first object has been to amplify and elaborate the pathological results comprehended in my former report, to confirm what was left imperfectly established, to elucidate what was obscure, and to endeavour to bring the inquiry into more direct bearing on the most important of all etiological questions, that of the origin and development of tuberculosis in man.

Structural characters of tubercle.

It has been already said that in the liver, lungs, and some other organs, the material which constitutes the new growth presents uniform structural characters which, although they are met with in many other parts of the body, are most distinct in the alveolar pulp of lymphatic glands. To imply this resemblance I proposed to designate these characters by the word *adenoid*. My further inquiries lead me to believe, in the first place, that these characters belong much more generally to tuberculous growths than I had at first supposed; and secondly, that those normal tissues which possess them are much more liable to become the seat of the tuberculous process than others. To illustrate these points it will be necessary not only to refer to my own observations, but to render available all the discoveries which have been made during the last six or seven years which bear upon the question.

* Fox, loc. cit. p. 20. Cohnheim, l. c. p. 219.

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On the Inoculability, &c. of Tubercle, by Dr. Sanderson.

Characters and Anatomical Distribution of natural Adenoid Tissue.

The existence of the tissue in question has been for some years recognized by all minute anatomists. Kölliker first described it under the term "*cytogene Bindesubstanz.*" For the more complete elucidation of its structure and significance, science is indebted to Professor His of Basle, who first applied to it the term "*adenoide Substanz.*"* Other histologists speak of it as *netzförmige* or *reticuläre Bindesubstanz, Zellengerüst*, &c. Kölliker defines the tissue generally as "a reticulum "of stiff, pale fibres, comprising lymph corpuscles in its meshes, "originating by the combination of branched cells, consisting neither of "gelatigenous nor of elastic substance, but of an albuminous compound, "soluble in caustic alkali, but not in boiling water."

Reticular cytogenic tissue is to be found in the lymphatic glands, in the spleen, in the neighbourhood of the ducts of the liver and of the bronchi in the serous and mucous membranes, and in the medulla of bone. I proceed to refer to its character and distribution in most of these organs.

Structure of the adenoid pulp of the lymphatic glands.

The structure of the lymphatic glands has been understood by anatomists only for a short period.† A few years ago it was supposed that a lymph-gland consisted essentially in a network of finely-divided lymphatic vessels, compacted into a dense mass by cellular tissue, and abundantly supplied with blood vessels. It was imagined that the afferent lymphatics divided into minute branches which, after forming an intricate plexus in its interior, combined again to become the efferent vessels. Somewhat more recently it was recognized that the afferent lymphatic channels were not continuous with the efferent as such, but that they lost themselves in certain holes filled with cells, since called alveoli, from which the efferent vessels took their origin. The first step towards a more exact knowledge of the subject was taken in 1852–53, when Brücke ‡ and Donders § showed that these holes were not mere dilatations of lymphatics, but that they contained structures of considerable complication; that in addition to the lymph corpuscles, which were before thought to be the sole occupants of the alveoli, each alveolar cavity is permeated by a network of transparent fibres. They further showed that this network is so arranged as to form a flask-shaped body (since called by His an ampulla), the contour of which corresponds to that of the cavity (alveolus) which it occupies, being, as it were, suspended in it by delicate strings of transparent connective material which stretch across the space between its outer surface and the inner surface of the alveolus. Thus the structure of the medullary substance of a lymphatic gland (in the part in which the alveoli are) may be described as follows:—It consists of a number of flask-shaped cavities, communicating with each other by their necks, enclosed in a meshwork consisting of beams and septa, all of which spring from the general capsular investment of the gland, and tend towards the hilus. These have for their

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* Kölliker, Handbuch der Gewebelehre des Menschen, pp. 58 and 64. Prof. W. His, Beiträge zur Kenntn. der zum Lymphsystem gehörigen Drüsen, p. 65.

† If it were necessary to seek for a reason for introducing these details into this Report, I should find it in the fact that even in the later editions of English text books of physiology the structure of the lymphatic glands is still described as it was known to anatomists of 20 years ago.

‡ Brücke, Sitzungsberichte der Akad. der Wissenschaften zu Wien. March 1853, p. 429.

§ Donders, Physiol. des Menschen, Band I. (Theile's translation), p. 318.

exclusive function to support and enclose the more important and more delicate structures which are contained in the alveoli, as well as the lymph vessels and blood vessels which belong to them. Thus the alveoli along with the tubular channels of communication between them form one many-chambered cavity, which cavity is occupied by a structure of the same contour as itself, attached to it, as I have said, by innumerable threads or bands of extreme tenuity. This compound body might be compared to a bunch of grapes in which each little stalk joins some other, instead of all combining to form one principal stalk; the stalks (which receive the name of medullary cylinders), being attached to the communicating channels in the same way as the ampullæ are to the alveoli.*

Such being the general arrangement of the alveoli and their contents, it remains to advert to their relations to the lymph stream, and the formation of lymph corpuscles, a subject which has a close relation to the pathological process it is our present object to study. The ampullæ as well as the medullary cylinders consist of a network of extreme delicacy, the interspaces of which are entirely occupied by lymph corpuscles. The ampulla is not covered by any membranous investment, the only difference between the surface and the enclosed pulp being that at the outside the meshes are much smaller, and the minute fibres are much more closely felted together than they are towards the centre. Nor is there any distinction, as regards the structure of the fibres themselves, between those which form the fine meshwork of the ampullæ and those which form the fibres by which they are suspended to the internal surface of the alveolus, excepting that the latter are somewhat coarser.

From the examination of glands naturally or artificially injected it has been ascertained that the afferent lymphatic vessels, after they penetrate the capsule of the organ, spread over the surface of the

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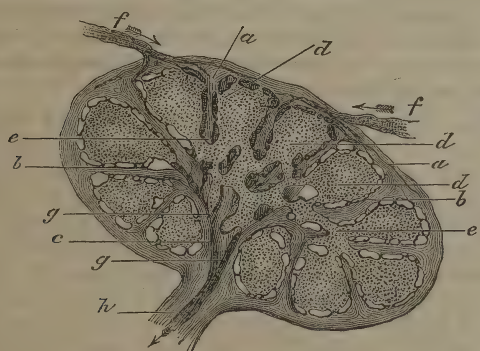
* In illustration of the description in the text, the following diagrammatic section of a lymphatic gland, copied from Frey, may be of service :—



a, capsule; *b*, dissepiments between the *alveoli*, all of which are continuous with the capsule and converge at *c* towards the *hilus*: *d*, *ampullæ*; each *ampulla* occupies an *alveolus*, to the surface of which it is attached by bands or threads, which cross the lymphatic sinuses; *e*, medullary cylinders; *f*, afferent lymphatic vessels; *g*, efferent lymphatics, uniting at the hilus into one trunk, *h*.

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adjacent medullary substance, finding their way immediately to the spaces surrounding the ampullæ and their connecting cylinders. How the lymph sinuses open into the numerous and minute lymphatic branches which combine to form the efferent trunks is not even now accurately determined. The fine network of the ampullæ is richly supplied with vessels, the arrangement of which in relation to that structure may be seen in Plate IV., Figs. 2 and 3 (see explanation). The arteries from which these capillaries derive their supply enter the reticular tissue by penetrating the medullary cylinders, and continue their course along the axes of these cylinders towards the ampulla, each being usually accompanied by a vein.

From the preceding short sketch of the anatomy of the lymphatic glands, which I have verified in its leading particulars in the lymphatic glands of guinea pigs, it appears that in their relation to the adenoid tissue which constitutes the ampullæ and cylinders, there is a complete antagonism between the lymphatic and blood circulation. Whereas the blood capillaries are richly distributed throughout the adenoid tissue, the lymph stream is separated from it by the densely felted fibres within which that adenoid tissue is comprised.

Adenoid pulp of Peyer's follicles and of the *Trachom-drüsen.*

It is now well known that Peyer's follicles have a structure which, although simpler, altogether resembles that of the ampullæ of the lymphatic glands. A Peyer's follicle is a mass of adenoid pulp of which the projecting part is covered by epithelium, while the convex under surface is surrounded by a lymph cavity, which can be injected from the lymphatic system, corresponding in every respect to the alveolar sinus of a lymph gland, the only difference being that whereas no epithelium can be detected in the latter, it has been distinctly made out in the former. Along the intermediate zone (so-called equator) the adenoid pulp of the follicle is continuous with the similar tissue of the sub-mucous layer. Peyer's follicles, like those of the lymph glands, are abundantly supplied with capillary blood vessels which have the same arrangement precisely as in the ampullæ.

Similar adenoid follicles are met with in other parts of the body. Thus in the conjunctiva there are globular masses of vascular cytogenic pulp (*Trachom-drüsen*), each of which is partly surrounded by a lymph sinus, just in the same way as the ampullæ of the lymphatic glands. In the adenoid follicles of the tonsils and in the follicles at the root of the tongue, which in every other respect closely resemble the others, this relation has not as yet been made out.*

Adenoid pulp of the spleen.

In the spleen we have an organ in which adenoid tissue exists in larger proportion than even in the lymphatic glands. Its relation, however, to the blood vessels is entirely different. It can be readily made out in the guinea-pig that, although the largest arteries are surrounded by common connective tissue, the rest are provided with sheaths of adenoid tissue which closely resemble the medullary cylinders of the lymphatic glands, and that the malpighian corpuscles are formed by the outgrowth of these cylinders into the form of spheroidal tubera, which either surround them or project from them laterally. As is well known, the arteries very rapidly divide, first into small arterioles and then into minute capillaries, some of which go to the malpighian corpuscles, others to the so-called pulp. Of this pulp all that can be said is that it is an exceedingly fine adenoid reticulum, which fills the whole of

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* Bruch, Zeitsch. f. w. Zool. B. iv. p. 297, 1854.

the space not occupied either by the malpighian corpuscles, or by the venous channels which permeate the spleen in all directions. What becomes of the arterial capillaries in this tissue has been until lately an open question, for it has long been recognized that they do not communicate directly with the veins. The recent investigations of Frey seem to show in the most conclusive manner that they actually lose themselves in the adenoid reticulum through which the blood filters into the innumerable venous channels which pass in all directions through the pulp. It is interesting as well as important to notice that in the spleen just as in the lymphatic glands, the three tissues of which it is constituted are not separated from each other by any membrane. The whole arrangement of the organ depends on the form of the reticulum, which is everywhere of the same nature, differing only in the degree of tenuity of the fibres and the size and form of the meshes, so that the reticulum of the malpighian corpuscles, of the arterial sheaths and of the pulp, constitute but one framework continuous throughout.

Distribution of adenoid pulp in the mucous and serous membranes.

In all the instances hitherto referred to the adenoid tissue forms whole organs, the functions of which depend on the reaction of the tissue itself on the blood or lymph which circulates through it. But there are other parts of the body in which the same structure is to be found, not consolidated into masses of definite contour, but scattered in layers which for the most part lie underneath or form part of the skin and mucous and serous membranes. It is necessary to study these adenoid expansions, with reference to the reaction upon them of the tuberculous infection. The field of research is so large that the view I am able to give of them must be necessarily incomplete.

Peritonæal adenoid tissue.

In my last report I described certain bodies as existing in relation with the arteries of the omentum of animals infected with tubercle, in the form of nodules, varying indefinitely in size, the largest being comparable to hempseeds. From the more minute and careful examination of them which I have since made, I have learnt that these visible granulations are strictly speaking not new growths but overgrowths, and that they originate by the enlargement of previously existing organs, not by the development of any heterogeneous structure. These organs have been little noticed by anatomists. The only reference which I find to them is in the last edition of Prof. Kölliker's "*Handbuch*" (p. 603), where he describes certain globular prominences consisting of cells resembling lymph corpuscles along with proliferating epithelium cells, as always to be found on the surface of the human peritonæum, and particularly of the *omentum majus*. Further, Dr. Knauff of Heidelberg, in two very recent papers,* describes certain organs under the designation of "lymphatic nodules," as constantly to be found in many parts of the serous membranes, and clearly recognizes the close relation between them and miliary tubercle. To these researches I shall have further occasion to refer, and content myself for the present with remarking that my own observations were complete before I became acquainted with them. It is probable that organs of the same kind exist not only in the pleura and peritonæum but also in synovial membranes, and they have a close relation with the villous structures which border the articular cartilages.

In the peritonæum of the guinea pig I have studied these bodies,

* Knauff, Zur Histologie des Miliartuberkels auf serösen Häuten (vorläufige Mittheilung). Centralblatt, Aug. 17, 1867. Knauff, Ueber das Pigment der Respirations Organe. Virch. Arch. vol. xxxix. p. 443.

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chiefly in those parts of the membrane which are the constant seat of tuberculous disease, viz., in the omentum and in the double fold of membrane which encloses the pancreas, and extends from that gland to the greater curvature of the stomach and the duodenum in its long course from the pylorus to the orifice of the pancreatic duct. These layers are continuous in front with those which in this animal go to form the omentum, a structure which differs widely from the omentum majus of human anatomy, both in its position and relations. Instead of stretching as a veil over the mass of intestines, it occupies a concealed position along the greater curvature of the stomach, to the convex surface of which it not unfrequently adheres. In order to examine these structures satisfactorily, the best method is to open the abdominal cavity from the front, and fill it with serum or some other indifferent liquid. By this means the omentum, which is of extreme delicacy, can be made to float, and thus dissected out without risk of injury. My invariable plan is to sever the peritonæal attachments of the spleen and pancreas on all sides under liquid, and then to remove the two organs together, and spread the membranes on a large plate of glass for examination under the dissecting microscope.

The omentum consists in its most transparent parts of two layers of epithelium, enclosing a regular network of connective fibres, the meshes of which are remarkably uniform in size, measuring about $\frac{1}{400}$ of an inch. The epithelium is formed of cells with wavy outlines, each containing a spheroidal and finely granular nucleus. These cells cling closely to the fibres of the network, never extending over the empty spaces between them, in consequence of which the nuclei project visibly from the surface. The relation of the arteries and veins to these two essential elements of the structure, viz., the epithelium and the network of structureless transparent fibres, differs according to their size. The smallest vessels, whether venous or arterial, are in immediate contact with the epithelium (see Fig. 2, Plate VI.). The vascular wall is connected on either side with the fibres of the network, with the substance of which it appears to be intimately blended. The larger vessels are enclosed in sheaths, of which, although they vary considerably in their structure according as they are studied in the omentum or in the mesentery, two principal varieties may be distinguished, those which contain fat cells, and those which consist entirely of adenoid tissue. Of the first kind a complete idea may be gained from Plate II., Fig. 1, which represents a vascular anastomosis from the mesentery. Each artery with its accompanying vein is enclosed in a flattened cylinder, of which that part which is next the vessels consists of fat cells, whereas the external part is of transparent adenoid tissue which could not be distinguished from that of a lymph gland. Vessels of size intermediate between those last described and capillaries lie in a mass of adenoid pulp, which sometimes forms a tubular sheath of uniform diameter, sometimes projects from the serous surface in the form of fringed appendages, extending along the course of the vessel, or spreading out between the epithelial layers.

From the masses of adenoid pulp which surround or fringe the vessels, to the adenoid nodules previously referred to, the transition is easy. These bodies are in fact collections of the very same material. They occur in the peritonæum in a variety of forms, of which the following are examples :—

Form *a*. Mere aggregations of cells, between the opposed layers of epithelium, not supplied with vessels. These occur very frequently in the omentum, in some parts of which they exist in great numbers.

One of them is shown in Plate II., Fig. 3. The lymph corpuscles are seen to be embedded in the substance of the same transparent material as that of which the fibres of the omental network are composed, which have become blended together into a hyaloid capsule of an oval form for their reception. These non-vascular nodules are usually much larger than the one represented, which was selected in order that the whole of it might be comprised within the field of the microscope.

Form *b*. Collections of cells around loops of intermediary vessels. One of these is shown in Plate I., Fig. 4. An arteriole after leaving a larger trunk runs a short course between two opposed layers of epithelium, towards a mass of adenoid pulp. From this mass a vein *larger* than the artery returns by the same course.

Form *c*. An arteriole (Plate I., Fig. 1 *a*.) terminates in a labyrinth of capillaries not at all unlike a renal malpighian tuft, out of which the vein emerges, and after joining another vein from a similar tuft soon finds its way to a venous trunk. Other forms might be referred to, but most of them are modifications of those already described. In intimate structure the vascular sheaths and isolated masses are alike. All are collections of lymphoid corpuscles embedded in an extremely delicate reticulum and covered with epithelium.

The epithelium covering the adenoid masses is continuous with the general epithelial lining of the peritonæal cavity, but differs from it materially. Plate VI., Fig. 2, illustrates the fact that wherever a capillary artery or vein occupies the space between the two layers of epithelium, the epithelial elements not only become more or less oblong, but arrange themselves in a direction parallel with that of the axis of the vessel. When larger vessels lie immediately underneath the surface the same arrangement is observed. Fig. 4 on Plate II. shows the epithelium covering an artery and vein, which are bordered on either side by an adenoid fringe. Over the whole of the fringe the epithelium can be traced, but it is seen that the form and size of the elements are different; instead of being large oblong plates with sinuous margins, they look like round scales. This appearance corresponds evidently to the proliferated epithelium of Kölliker. It is to be found without exception over every mass of adenoid tissue when examined by v. Recklinghausen's method; but in preparations stained with carmine it cannot be recognized, the nuclei of the epithelial elements when coloured by that reagent looking exactly like lymph corpuscles.

The relation of the adenoid tissue to the vessels has been investigated by two methods. In some of the experiments, I injected a solution of carmine containing one drachm in two ounces of water, about two hours before killing the animal, into the peritonæal cavity, in the manner practised by Prof. Chrzonszczewsky of Kasan. The effect of this process is remarkable; all the masses of adenoid pulp are coloured, so that in those parts of the peritonæum in which they are numerous the surface looks as if it were scattered with red dots. Under the microscope it is seen not only that the lymph corpuscles are stained, but that the veins leading from them are filled with carmine. These appearances at first suggested that the distended channels were in truth not veins but lymphatics, but on tracing them to their destination I soon satisfied myself of their real nature. By this method I also learnt that wherever the adenoid pulp is in relation with blood vessels, it is itself richly supplied with blood. These capillaries are so large that when the tissue is examined in glycerine they often seem to constitute the whole mass, completely concealing the cells. Whether they communicate or not directly with the arteries, or like the venous channels of the

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spleen receive their blood from inter-corpuscular spaces, seems to me to be a question yet to be determined. With reference to it, it is to be noticed that the capillaries demonstrated by this method can always be traced into efferent venous trunks, but cannot, so far as I am able to observe, be shown to be continuous with arterioles, and that the efferent vessels are always either larger or more numerous than the afferent. In addition another fact is to be borne in mind, which although mainly pathological, may not be exclusively so, viz., that the veins leading from adenoid masses are, when the latter are excited by the tuberculous infection, often filled with colourless corpuscles (see Plates I. Fig. 3, and VIII., Fig. 4). So far as relates to the vascularity of adenoid tissue in the diseased state, my injections of the diseased parts from the cœliac axis show that the tissue is richly supplied with arterial capillaries, the arrangement of which cannot fail to remind one of the manner in which the arterial capillaries of the spleen are distributed to the sheaths of adenoid pulp. As regards the relation of the adenoid masses in the peritonæum to the lymphatic vessels, I confess myself to be entirely at fault. In applying v. Recklinghausen's method, I have failed to discover any lymphatic channels, nor am I aware that anyone else has met with them in this part of the peritonæum.

Physiological signification of the adenoid tissue of the peritonæum.

The above details render it possible to enter on the consideration of the physiological significance of these masses. From their structural analogy to the splenic pulp, it is scarcely possible not to suppose that they have similar functions, *i. e.*, that they are concerned in the elaboration of blood corpuscles, while, on the other hand, their resemblance to the adenoid structures of the mucous membranes suggests that they are probably concerned in absorption, and that they stand in the same relation to the peritonæal cavity that Peyer's follicles and the rest of the adenoid tissues of the intestine do to the alimentary canal. The latter view seems probable, from the similarity of the conditions under which they show signs of excited action with those which affect, in a corresponding manner, the lymphatic glands and the intestinal follicles. In animals that have died of acute peritonitis all these adenoid masses become soft, tumid, and enlarged.* If the smallest possible amount of tuberculous material, suspended in water, is injected into the peritonæum, these organs undergo a more gradual hyperplasia, and eventually become tuberculous. This delicacy of reaction against an infective agent seems to me to be more easily understood by supposing that the morbid material actually passes through the excited tissue than in any other way.† In suggesting that the peritonæal adenoid masses, as well as adenoid tissues everywhere, play an important part in the development of the blood corpuscles, I am partly influenced by the observation already referred to, namely, that under certain circumstances not fully determined, colourless blood corpuscles are contained in extraordinary numbers in the veins leading from them, and partly by my inability to think of any other final cause for their existence. I have been further

* In confirmation of this statement, see an observation published by Professor Klebs since the above was in print, who has observed the same fact, but attributes it to emigration from the capillaries of colourless blood corpuscles! Klebs, Handbuch der pathologischen Anatomie, 1869, p. 318.

† In confirmation of this conclusion I would refer to the following experimental result (March 31st). In three guinea pigs inoculated 21 days previously, by the injection of a drop of distilled water rendered turbid with pounded diseased lymphatic gland, no lesion was found excepting that the adenoid masses (Knauff's bodies) in the anterior mediastinum were enlarged to such an extent that when the membrane was spread out on a glass plate, they could be readily distinguished without the aid of a lens, as transparent beads.

very strongly confirmed in my surmise since I have become acquainted with the recent most important researches of Neumann as to the development of blood corpuscles in the cytogenic tissue of the medulla of bone, and the still more satisfactory observations of Bizzozero on the same subject.*

In the alimentary canal adenoid reticular tissue is very generally distributed underneath the mucous surface, and wherever it occurs it has important relations with infective morbid processes. In addition to the follicular glands analogous to those of Peyer, which have been already referred to,† there are masses or layers of the same material in the mucous membrane of the fauces and pharynx as well as in that of the small intestine. In the latter situation, indeed, adenoid pulp constitutes the great bulk of the mucous tissue, forming a continuous stratum the deep surface of which is separated from the muscular fibres by the connective tissue and vessels, its upper limit being the so-called basement membrane of the epithelium, with reference to which it is now known that it is not in any true sense a membrane, but is merely due to a superficial condensation of the delicate reticulum which pervades the whole mass. Everywhere throughout the small intestine the adenoid pulp is in relation with the submucous network of lymphatic channels, which over the whole of the villous portion of the small intestine are of great width and exceedingly numerous.‡

The mucous membranes which line the respiratory cavities, and particularly the pulmonary air tubes, possess no adenoid tissue resembling that of the alimentary canal. In the guinea pig, as in other mammalian animals, longitudinal elastic fibres and transverse muscular fibres lie immediately underneath the epithelium of the bronchial tubes, outside of which comes a layer of common connective tissue, in which more or less imperfect cartilaginous rings are enclosed. Anatomists have not described any glandular structures excepting the acinous mucous follicles which occur here and there beneath the mucous membrane of the larger bronchi.

Distribution of natural adenoid pulp in the healthy lung.

In my former report I stated that in the irongrey nodules which result from tuberculous inoculation two kinds of cells are met with, namely, large nucleated cells which I identified with those naturally contained in the alveoli, and smaller bodies not much larger than blood corpuscles, which I regarded as the essential elements of the morbid growth. Following out the line of inquiry which my observations as to the development of tubercle in the peritonæum had suggested, I devoted much attention to the examination of the healthy lung in the guinea pig, for the purpose of ascertaining whether or not masses of adenoid pulp are to be found in it, particularly in those parts which appear to be the favourite starting points of tubercle.§ From the examination of a number of specimens, I have ascertained that masses of cytogenic tissue of irregular form are always to be found in the neighbourhood of the bronchi. Those which are in relation with the smaller branches lie in the loose

* Neumann, Bedeutung des Knochenmarkes für die Blutbildung (vorl. Mittheilung), Centralblatt, Oct. 10, 1868. Bizzozero, Sulla funzione ematopoietica del Midollo delle Ossa. Gaz. Med. Ital. Lombard. 1868, No. 46.

† See Huxley on the Tonsillar Follicles, Microscopical Journal, vol. ii. p. 74. See also von Luschka. Das adenoide Gewebe des menschlichen Schlundkopfs, Schultzes Archiv., B. iv. 1–9.

‡ For a complete and exhaustive account both of the tissue itself and of its vessels, see Frey, "Ueber die Chylusgefässe der Dünndarm-schleimhaut, und über die Lymphbahnen der Peyer'schen Drüsen," Zeitschrift für w. Zoologie, B. xiii. S. 1–28.

§ The only structures containing adenoid tissue which have been referred to by anatomists as existing in the lung are the so-called *glandulæ pulmonales* (lymphatie glands in the neighbourhood of the larger bronchi).

common connective tissue by which these tubes as well as the blood vessels are separated from the air cells, while those which lie near bronchi of sufficient size to be possessed of cartilages, are found to lie in a corresponding position outside of the fibrous layer in which the cartilages are embedded. In every instance I have found the adenoid masses occupying a position between the air tube and the nearest artery, with the outside of the adventitia of which the surface of the mass is usually, if not always, found in contact. It was never, however, observed that the arterial adventitia was in the slightest degree modified, so that the mass could not be regarded as a development from that structure. It is further to be noticed that in injected lungs the masses were found to be vascular, minute capillaries not only ramifying on their surface, but penetrating into their interior. I am unable to state anything from my own observations as to the relation of these bodies to the lymphatic system; but inasmuch as they lie in the course of the absorbent vessels (see p. 116), I have no doubt that they are in direct relation with the lymph stream. (See Plate V., Figs. 2 and 3, and Plate VIII., Fig. 3.) From their position relatively to the bronchi and arteries, it became evident to me that these normal masses of adenoid pulp correspond anatomically to the much larger abnormal collections of similar material which in my last report I described as peri-bronchial granulations.

In the liver, strata of adenoid pulp are also to be found in the healthy condition of the organ, the distribution of which is analogous to that which I have described above. The tissue stands in the same relation to the branches of the portal vein and the bile ducts that it does to the pulmonary arteries and bronchi. I have not, however, as yet met with definite masses like those which are to be seen in the lungs, nor am I able to state how far the tissue can be traced along the ramifications of the portal ducts. It cannot, I believe, be demonstrated in the interlobular spaces.

Additional Observations as to Tuberculosis of the Lymphatic Glands.

I have now to bring the anatomical facts stated in the preceding paragraphs into relation with the morbid processes which constitute tuberculosis. In doing so, it is clearly most advantageous to consider those which have their seat in the lymphatic glands and in the spleen, not merely because I gave only a general and preliminary account of them in my last report, but because the reaction of the tuberculous infection on the *normal* adenoid tissue of which these organs so largely consist, is the type and pattern of the changes to which the similar *adventitious* tissue is subject elsewhere.

The diseased conditions of the lymphatic glands (excepting so far as their rough pathological anatomy is of practical interest to the surgeon) have been very little studied, so that in beginning the investigation of any of them one is breaking new ground. The reason why so little is known of the subject is obvious; until lately their normal structure was not understood even in its broad outlines.

My dissections have all been made by the process first, I believe, employed by Billroth, about ten years ago, and subsequently so successfully and so extensively applied by His, to the investigation not only of the structure of the spleen and lymphatic glands, but of many other organs—the method of pencilling out thin sections of the hardened tissue with a sable brush held vertically. Fresh sections of the spleen or lymphatic glands, whether prepared with the double-bladed knife or otherwise, show absolutely nothing of the structure. All that can be seen is a confused mass of cells. Sections of the same organs, after hardening

in chromic acid or alcohol, are much more instructive, but still the observer is embarrassed by the innumerable multitude of cells, which seem so closely packed that there can be no room for any other elements. By pencilling such a section in the manner above referred to, a vast number of these bodies are removed, whereas, if proper care is taken, the reticulum in the meshes of which they are contained remains unaltered. The application of this method in the investigation of the lymphatic glands is specially valuable, for it affords a ready means of differentiating the two principal textures which enter into its composition—the medullary and the cortical—and of bringing into view the ampullæ with their surrounding lymph-sinuses.

The lymphatic glands are subject to two distinct morbid alterations in tuberculized animals, both of which were referred to in my former report as affecting subcutaneous and internal glands respectively. The subcutaneous glands are affected only secondarily, that is, in consequence of local changes going on at the seat of injury, consequently none of them become diseased excepting those that receive tributaries from diseased parts. The morbid changes produced are more or less acute and lead to softening and suppuration. The alteration consists in enormous and rapid enlargement of the organ, consequent on multiplication of cells. The alteration appears to affect all the parts of the gland alike, but does not in its early stages alter its structure. It may be said to consist primarily mainly in congestion, and in the multiplication of cells in such enormous numbers as to destroy the consistence of the gland. Minute collections of free cells (purulent foci) become disseminated throughout its substance, by the confluence of which the whole is converted into an abscess. In the meantime the capsule of the organ becomes thickened by the interstitial development of new connective tissue, within which may usually be found a layer of gland-substance, which instead of softening has undergone the gradual process of induration to be immediately described.

In the internal lymphatic glands the origin of the morbid alteration is always tertiary—that is to say, it is a consequence of secondary disease existing in the organs from which they receive their afferents. These alterations are chronic in their character, and are never attended with suppuration. I have studied them principally in those glands which receive the lymphatics of the liver, and are situated in the *ligamentum hepaticoduodenale*, close to the portal vessels. The changes observed are of the following nature. In the early stages nothing is seen excepting that the alveolar reticulum is perhaps somewhat coarser than it should be. (Plate IV., Figs. 1 and 2.) All the constituent parts of the organ can be readily distinguished from each other, and the lymphatic sinuses seem to be pervious and in a natural state. The further progress of the alteration is marked by the diminished distinctness of the structure. It becomes more and more difficult to distinguish the alveoli from the trabecular tissue by which they are separated from each other. This appears to arise from two distinct processes. In the first place, cells are developed in great numbers in the fibrous tissue which constitutes the external capsule of the organ as well as the septa or partitions which separate the alveoli from each other. These cells differ from the ordinary lymph corpuscles in their larger size, and in the fact that most of them are distinctly nucleated. They are arranged in round or oblong groups enclosed in the meshes of the fibrous tissue, or more properly speaking, in cavities which they have made for themselves. In this way the trabecular tissue loses its natural compactness, and assumes the character of a spongy reticulum, the interstices of which, however, are

much larger than in that of the alveoli. In the ampullæ a change occurs which at first sight appears to be of an opposite nature. The slender fibres of the alveolar reticulum become coarser. Towards the centre of the ampullæ this thickening seems to affect all the fibres equally, so that a fine network of threads is converted into an equally fine network of transparent cords, the holes of which, notwithstanding the general enlargement of the whole mass, are much smaller than they were before. Towards the surface of the ampullæ the process consists in the formation of irregular bands of fibrous material traversing the original tissue at various distances and in various directions, by which the lymph spaces are obliterated and the whole converted into a coarse sponge, and thereby assimilated to the altered cortical tissue with which it is continuous. All this might be expressed more shortly but less completely by saying that the whole of the medullary part of the gland becomes the seat of fibrous degeneration, which, while it principally affects the dissepiments, extends from them to the alveoli, converting all the affected parts into a fibrous sponge in the interstices of which are contained cells usually larger and more distinctly nucleated than lymph corpuscles.

Up to this point the altered gland tissue is still supplied with blood, for in specimens of which the arteries are injected it may be seen to be pervaded with vessels in all directions. The vascularity, however, is I believe confined to the trabecular tissue, for the fibrous degeneration of the fine tissue of the ampullæ necessarily involves the obliteration of its equally delicate capillaries, or rather their conversion into fibrous bands indistinguishable from the rest of the tissue. The part which the corpuscles take in this process of fibrous transformation must, I venture to think, be exceedingly subordinate. In the ampullæ the natural lymph cells totally disappear, so that in those parts of the gland in which the fibrous change is most complete there are no cells whatever, as one may easily satisfy oneself by the examination of unpencilled sections. In those parts where there are still heaps of cells contained in the meshes of the sponge, these appear to have nothing to do with the development of the fibres which surround them. The ultimate result of the process is caseation, *i.e.*, slow necrosis. The fate of the cells is to die, of the fibres to become opaque and granular. Why this happens scarcely needs explaining. For even if we refuse to admit that an adventitious tissue is in itself less alive than the tissue which it replaces, the mechanical effect of such a transformation as has been described must be to produce anæmia and consequently slow death. As to the chemical nature of the material deposited I have little to say. It is very translucent, never striated or granulous, and is very readily stained by solution of carmine.

The relation of the morbid process to the functions of the organ can scarcely be doubted. From the moment that the intra-alveolar network becomes transformed into ordinary fibrous tissue, all activity must be at an end; as the degeneration progresses the lymph stream must be entirely stopped, and all the tributaries leading to the gland obstructed. Thus in every case in which a diseased organ induces fibroid degeneration of its lymphatic glands, those glands must react on the organ itself by obstructing its lymphatic capillaries.

The changes which occur in the spleen correspond so closely with those observed in the lymphatics, that they scarcely need a separate description. The development of the disease is divisible into two stages. It begins, as in the lymph glands, by a rapid cellular proliferation, in consequence of which the organ increases enormously in size. The

multiplication of cells occurs, as I stated last year, principally in the malpighian corpuscles, in consequence of which these bodies become unnaturally prominent and obvious, and assume in every respect the character and appearance of miliary tubercles. By the overcrowding of the cells the blood vessels are compressed, so that the central parts become anæmic and undergo caseous degeneration. Eventually the spleen undergoes a fibroid degeneration, the characters and results of which are similar in every particular to those already described in the lymphatic glands. The pulp and the malpighian corpuscles, which in the guinea pig are remarkably well developed, especially underneath the convex surface, and form by far the greater part of the bulk of the organ, soon become indistinguishable. This blending of dissimilar types of structure takes place just as in the lymphatic glands. On the one hand the capsule is everywhere thickened, and here and there bulges out into nodular prominences in consequence of the irregular growth of groups of cells in the interstices between its fibres, while on the other the bands of newly formed fibrous material spread in every direction through the pulp. The final result of the transformation resembles that which I have already described so closely, that if it were not for the more regular arrangement of the trabeculæ it would be impossible to discriminate between sections of the two organs (see Plate VII., Figs. 5 and 6).

Additional Observations as to Tuberculosis of the Skin.

As to the primary local effects of inoculating tubercle or of introducing other irritants into the living tissues of the guinea pig so as to induce tuberculosis, results of great importance have been recorded by other observers,* and particularly by Dr. Fox, since the date of the last report. In Dr. Fox's experiments the foreign matter was inserted under the skin. He admits that the most common local result is the formation of masses of cheesy matter which are dry and friable, ("débris of fattily degenerated material,") and are enclosed in capsules of firm semi-transparent and almost lardaceous appearance. But in addition to these encapsuled masses of caseous matter, he states "there are small granulations "varying in size from that of a poppy seed to that of a hemp seed, "which are irregularly scattered for a variable area in the subcutaneous "tissue." With respect to these masses, which are sometimes semi-transparent throughout, and sometimes have opaque centres, he remarks that "they present a striking resemblance to the naked eye, and also "under the microscope, to the changed lymphatic glands." The account he gives of their minute structure may be summarized as follows:— In their denser and more central parts they consist of nuclei embedded in an homogeneous tissue, in their less dense parts "a fibrillated tissue "which forms bands or trabeculæ between which the cells lie," the whole forming a structure which has "the strongest resemblance to the "elementary composition of a lymphatic gland, or to the cytogenic "tissue of His." "Throughout the granulations many of the cells "and also of the nuclei are seen in various stages of fatty degeneration. "The fat is sometimes in visible drops, sometimes in a finely molecular "form. The change is most common towards the centre of the granu-"lations, but it is also seen in cells irregularly scattered through the "adjacent tissue."

Of these subcutaneous granulations but little notice has been taken

* See Klebs, Ueber die Entstehung der Tuberculose u. ihre Verbreitung im Körper. Virchow, B. xliv. S. 242. Langhans has introduced the infective material beneath the conjunctiva of the eye, Klebs and Cohnheim into the peritonæal cavity. I have been unable to obtain a copy of Langhans' researches which are contained in an inaugural dissertation.

by other observers.* Their importance was overlooked in the account given of the local changes in my last year's report. Investigations which I have made with special reference to this subject enable me to confirm in every particular the accuracy of Dr. Fox's details. In animals that have been inoculated from three to four weeks with material taken immediately after death from the bronchial glands of other tuberculized animals, the only morbid alteration which can be discovered consists in the existence of a knot of hardened and thickened skin. On making a section of the diseased part, and examining it with a lens, it is seen that the hard mass lies immediately under the true skin, of which in fact it seems to form a part; and that it consists of an aggregation of smaller masses, separated from each other by more or less irregular bands of connective tissue. At a later period, that is to say, seven or eight weeks after inoculation, other nodules are found in the neighbourhood of the original one, which, excepting that they are more disseminated, resemble the little masses already referred to, each being enclosed in an indistinct capsule of reticular connective tissue similar in character to that which enters into the composition of the nodule. On examination of the smallest of these granulations in the recent state, nothing can be discovered excepting that it is a mass of round cells like lymph corpuscles. In sections of hardened tissue it is found that these corpuscles are enclosed in a fine meshwork of fibres. I have never seen this meshwork comparable in fineness to the alveolar reticulum of a healthy gland, from which, indeed, it differs in several important particulars. Not only are the septa thicker and coarser, but even in the smallest and presumably youngest granulations each cavity is large enough to contain several cells, whereas in the ampullary network the threads are never further apart than the diameter of a single corpuscle. If, however, the comparison be made between the adventitious tissue and the coarser network which occupies the lymph sinuses in the lymphatic glands, the resemblance is much closer, and it is still more striking as regards a lymphatic gland in incipient fibroid degeneration; so complete, indeed, is the correspondence of structure that the two are indistinguishable under the microscope. (See Plate VII., Figs. 3, 4, 6.) The cells which occupy the spaces between the fibres are for the most part similar to lymph corpuscles; in some no distinction can be seen between nucleus and cell, while in others there is a nucleus surrounded by a mass of less refractive matter, not much larger than itself. In addition to these ordinary lymph corpuscles I have always found a certain number of much larger nucleated cells, exact representations of which are given in Plate VII., Fig. 3 *a. b. c. d.*

In pencilled sections of single nodules it is found that the meshes of the network are much smaller in the centre of the granulation than near its periphery, so that in the latter situation there are open spaces not crossed by fibres of the reticulum, large enough to contain a considerable number of corpuscles, which can be as easily pencilled out of them as out of the medullary lymph spaces of the lymphatic glands. Of the relation of these subcutaneous nodules to the lymphatic capillaries I regret to say that I know nothing, as I have altogether failed to trace these vessels in the diseased tissues. Guided by the analogy of the adventitious to the natural adenoid structures, it seems extremely probable that the lymph stream passes through the peripheral network of the nodules in the same way that it does through the sinuses of the lymphatic glands. Sections under a low power show very distinctly

* Professor Lebert makes some reference to them in his paper on the communication of tubercle to animals in Virchow's Archiv., vol. xliii. They are also vaguely referred to by Villemin.

that these nodules are in the closest relation with the closely packed connective tissue in which the hair bulbs and cutaneous glands are embedded; they are separated from it, however, by a sharp line of demarcation.

In the loose connective tissue between the muscular and tendinous layers it is common to find minute granulations, some of which are so small as to require a lens for their detection. On superficial examination these might be regarded as of the same nature with those found in the cutis. That they are really inflammatory in their origin is indicated by the large size of the cells, and their obvious development from connective tissue corpuscles, as well as by the absence of any reticulum. I have never observed any change in the muscular or tendinous tissues themselves. (See Plate VII., Fig. 2.)

Observations relating to the Lymphatic Capillaries.

Until the publication of v. Recklinghausen's researches in 1862* it was not known by what sort of channels the lymphatic system commenced. In the few tissues in which anatomists had succeeded in filling them with injection, most observers, including Brücke and Ludwig, regarded them as mere interstices not lined by any membrane. v. Recklinghausen not only proved the existence of lymphatic capillaries but demonstrated their structure by the method to which I have already had occasion to refer. This method consists in subjecting the tissue to the action of an extremely weak solution of nitrate of silver (either by injection or imbibition) for a few seconds, and then exposing it to the light, by which means the chloride of silver first deposited in the substance of certain elements of the tissue assumes a reddish-brown colour. When this method is successfully applied to the examination of the lymphatics, a mosaic of dark-brown lines, (see Plate VIII., Figs. 1 and 2,) is brought into view; these lines correspond to the edges of the epithelial plates, or more properly to the interstitial cement which separates them from each other.

The arrangement and structure of the lymphatic capillary channels have now been satisfactorily made out in almost all the internal organs—in the lungs (Wywodsoff), in the liver (MacGillavry and Chrzonszczewsky), in the mucous membranes (His and Frey), in the pleura (Chrzonszczewsky, Afonassiew, Dybkowsky), in the peritonæum (v. Recklinghausen and Schweigger-Seidel). With respect to the last-mentioned structures, the original discovery of v. Recklinghausen that the serous cavities communicate with the lymphatic vessels, has been confirmed by the observations of Schweigger-Seidel and Chrzonszczewsky as regards the communication of the peritonæum with the superficial network of the lymphatic capillaries on the under surface of the diaphragm, by Dybkowsky as regards the costal pleura, and by Afonassiew as regards the pulmonary pleura; so that there can now be no doubt that these great cavities play a most important part, not only in the physiology of absorption, but in the diffusion and distribution of infective materials.

I have already stated that in the skin I have entirely failed in tracing the relation of tuberculosis to the lymphatic capillaries. Professor Klebs (of Berne), however, has been more successful.† His observations, although few in number, are clearly of great importance in their bearing on the question whether or not the absorbents are to be regarded as the channel by which tuberculous infection is conveyed. His principal ex-

* v. Recklinghausen, Die Lymphgefässe und ihre Beziehung zum Bindegewebe. 4to., Berlin, 1862.

† Klebs, loc. cit. p. 285.

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perimental results are as follows: a liquid consisting of finely comminuted cheesy tubercle from the lungs of a phthisical patient was injected in extremely small quantity with a hypodermic syringe into the peritonæal cavities of three guinea pigs. They were killed at periods of 30, 43, and 70 days after inoculation. In the first, miliary tubercles were found in the peritonæum at the point of insertion, in the serous investment of the liver, spleen and kidneys, in the diaphragm and in the lungs. In the second, the peritonæal lesions were similar but more extensive, in addition to which the mesenteric and bronchial glands were much diseased. In the third animal some of the organs affected in the preceding cases, and particularly the lungs, were free from disease, but the alteration of the bronchial glands was much more advanced, from which he concluded that they were infected directly from the diaphragm. In each case Klebs applied the method of v. Recklinghausen for the investigation of the condition of the lymphatics. It was found that the nodules, which were confined to the peritonæal surface, were smallest and most numerous on the *centrum tendineum.* In the most minute of these miliary granulations a very distinct relation could be traced between the arrangement of the cells of the new growth and the rectangular network of lymphatic capillaries, (discovered by v. Recklinghausen,) which lies under the epithelium. It was observed that wherever there were tubercles the network was interrupted, and that the smallest tubercles were often situated at the junction of several lymphatic channels. The author admits that the tuberculous mass spreads into the intermediary substance (*Grundsubstanz* of v. Recklinghausen), between the lymphatic channels, but states that at the edge of each granulation it "stretches out in processes," each of which corresponds to a lymphatic channel, within which he infers the new growth must have originated. He further believes that the epithelium of the lymphatic capillaries, which here as elsewhere consists of oblong plates with wavy contours, each containing an oval nucleus much smaller than itself, is transformed into "tubercle corpuscles;" or in other words that there is a proliferation of the lymphatic epithelium, similar to that which Rindfleisch * supposes to occur in tuberculosis of the omentum—the newly-formed cells first filling the lumen of the vessel and then bulging it out so as to take the place of the intermediary substance.

On the 24th of October I inoculated several guinea pigs by the method employed by Klebs. In three of these animals which were examined respectively on the 9th of January, the 19th of February, and the 10th of March 1869, I had the opportunity of verifying the perfect accuracy of his description, so far as relates to the distribution of tuberculous granulation on the peritonæal surface of the diaphragm; but I have been unable to trace any indication of the origin of lymphoid corpuscles from epithelial elements.

The results of my investigation of this question are as follows: The arrangement of the lymphatic vessels in the *centrum tendineum* depends upon that of the two tendinous layers of which the aponeurosis consists. Of these layers, the lower, which is the strongest, consists of fibres having the same direction as those muscular fibres of the diaphragm which take their origin from the ribs; so that they converge backwards and towards the middle line. The upper layer, which is much less distinct, has the same general direction as the muscular fibres which are inserted into the posterior edge of the central tendon. The fibres of the inferior layer are divided into bundles by splits or intervals of sufficient size to be visible to the naked eye. The lymphatic vessels on

* Rindfleisch, Lehrbuch der pathologischen Gewebelehre, p. 221.

the peritonæal aspect of the aponeurosis present themselves in two forms; (1) Sinuses or lacunæ, which lie immediately underneath the epithelium of the peritonæum, embedded as it were in the basement membrane (*Grundsubstanz* of v. Recklinghausen). (2) Radiating channels which occupy the spaces between the tendons. The lacunæ are of the most various forms; they are scattered very irregularly on the under surface of the central part of the aponeurosis, occupying a space greater than that of the intervals which separate them from each other. (See Plate VIII., Fig. 1.) They communicate by tubular channels so as to form a kind of plexus underneath the epithelium. Both the lacunæ and the channels of communication are lined with an endothelium of great beauty and regularity, consisting of plates which differ from those of the veins and arteries in their larger size and remarkably sinuous outlines, a peculiarity of form which renders it impossible to mistake them for any other epithelial structure in the body. They communicate directly with the deeper layer of intertendinous radiating vessels already mentioned, by which the lymph is conveyed towards the centre of the aponeurosis, there to be discharged into larger lymphatic trunks which, according to Ludwig and Schweigger-Seidel, tend towards the anterior wall of the thorax, and thus find their way to the thoracic duct. It is evident that if Professor Klebs is right in supposing that the tuberculous new growth is either contained in the lymphatic channels, or springs from their walls, the distribution of the diseased product in the tuberculized diaphragm must correspond to the arrangement of lymphatic vessels above described. My investigations afford no support to this supposition. They show (1) that as regards the tissue immediately underneath the epithelium, the arrangement of the nodules or granulations has no relation to the lymphatic lacunæ; and (2) that the radiating intertendinous lymphatics never contain collections of lymph corpuscles. The origin and growth of granulations on the under surface of the diaphragm consist here, as in the rest of the peritonæum, of the multiplication of corpuscles already existing and forming part of the affected tissue. By the examination of numerous healthy diaphragms, I have ascertained that normal adenoid tissue, presenting the usual characters, and differing in no respect from that which constitutes tuberculous granulations, is to be found under both layers of serous membrane, and that it exists in such abundance in the neighbourhood of the superficial veins on the peritonæal surface of the aponeurosis that it forms sheaths to those vessels. These sheaths are so distinct and well marked, that in diaphragms not stained but merely rendered transparent by steeping in glycerine, the course of the veins can be traced as opaque lines when the membrane is examined under a low power; the adventitia of the superficial arteries presents no such peculiarities.

In correspondence with these facts as to the natural adenoid pulp I found that in the animal examined on the 9th of January, all the numerous granulations which existed on the peritonæal surface of the diaphragm were in relation with vessels, and that in the smallest granulations it could be distinctly seen that the new growth sprang not from the adventitia of an artery, but from the adenoid sheath of a vein. From my later dissections it appeared that each granulation eventually projects above the surface of the membrane, first as a rounded elevation, then as a wart or papilla, being finally converted by the flattening of its apex into a round disc attached by the middle of one side to the surface of the membrane; the other side being in contact with the opposed surface of the liver. If other evidence were wanting that the tuberculous new growth does not originate from the walls of the lymphatic

vessels, it might be found in the fact, that although the distribution of those vessels on the upper and under surface of the membrane is so entirely different, the granulations found on the pleural surface were as numerous as those on the peritonæal and had the same arrangement.

Additional Observations as to the Structural Changes observed in the Liver.

The structure of the liver of the guinea-pig resembles very closely that of the rabbit, which has been minutely studied by Hering.* In hardened livers it is easy to demonstrate the arrangement of the intra-lobular capillaries. In sections at right angles to the intra-lobular vein they are seen to converge from all sides to the axis of the lobule. Extremely numerous near the periphery of the acinus, they diminish in number towards the centre, by the repeated confluence of two into one. Consequently all the capillaries tend towards the axis, so that in every section cut longitudinally the direction of the blood stream may be readily determined. Thus the capillaries may be regarded as a framework of radiating cylinders in which the liver substance is contained, filling up the whole of the space not occupied by the vessels; whence it necessarily follows that the liver substance, although in every section parallel to the general direction of the vessels, it looks as if it were divided into separate masses, cannot really be so ; and that in reality it must form a network of columns of cells, which, as regards the space it occupies is complementary to that formed by the capillaries. These columns do not (as appears to be the case in the rabbit) consist of single rows of cells; for it is almost always seen, when they are cut across, that at least two cells are divided.

The structure and mode of origin of the bile ducts, from their great importance in relation to morbid changes, require special consideration. In the guinea pig the smallest bile ducts are cylinders $\frac{1}{1100}''$ in diameter, with lumina measuring $\frac{1}{4000}''$. Each consists of a membranous tube enclosing nucleated cells, the nuclei of which are of the same size as those of the liver cells, and closely resemble them. In general these terminal tubes are to be met with only in the inter-lobular spaces; but they can be often seen to penetrate into the peripheral masses of cells. In certain laminar expansions of liver substance which are to be found on the outer surface of the portal lymphatic glands, I have been able to observe that these ducts lined with epithelium sometimes end in cylindrical columns of true liver cells, the arrangement of which, although much less regular than that of the epithelium, shows distinctly that they surround an axial channel. In this case the relation between the epithelial and gland cells corresponds completely to that which holds in reptiles. In these animals the glandular cells form cylindrical columns the constituent elements of which are arranged like epithelium in a regular and symmetrical manner round the axial duct. No such arrangement can be traced in the lobules of the guinea pig's liver, for here the acinous type of structure so predominates over the tubular that the latter is wholly indistinguishable. In the guinea pig the arrangement of the intra-lobular ducts is no doubt the same as in the rabbit, in which Hering has shown that they are minute channels hollowed out, as it were, in the walls of contiguous cells. These channels run in a direction parallel to that of the radiating capillaries, and are connected with each

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* Hering, Ueber den Bau der Wirbelthierleber, Sitz.-Berichte der Wiener Akad. d. Wissensch. Bd. liv. p. 336; Schultze's Archiv., Bd. iii. p. 88. See also Eberth, Untersuch. über die Leber der Wirbelthiere, Schultze's Archiv., Bd. iii. p. 423.

other by cross branches of communication, so that the whole assumes (when seen in a longitudinal section) the appearance of a network of oblong spaces; whence it necessarily follows that each bile channel occupies the axis of one of the columns of liver cells already described. The return of the structure to the original tubular type, when no longer compelled to conform to the general acinous plan on which the organ is constructed in the higher animals, will be seen to have an important pathological bearing as indicating that the epithelial and gland cells are in reality homologous structures.

The capillary framework of the acini may be demonstrated in the healthy liver by the method of His. (See Plate III., Figs. 1 and 2.) In examining the capillaries thus exposed, it is seen that in addition to their considerable diameter as compared with capillaries elsewhere, they look as if they were surrounded by a continuous sheathing of apparently homogeneous membrane irregularly scattered with round cells, the nuclei of which are readily stained by carmine. In the human liver the appearance is perfectly similar. The researches of MacGillavry* have shown that this sheath belongs to the lymphatic system. He has found by injection that in the liver, as in the brain, the capillaries are surrounded by lymph channels which in fact are the beginnings of the absorbent system of the gland. Following the capillaries towards the periphery of the lobules, they enter the larger lymphatic channels, which stand to the ducts in a relation similar to that in which the pulmonary lymphatics stand to the bronchi. At the hilus and in the ligamentum-hepatico-duodenale they pass through a number of lymphatic glands, and are no doubt in close relation with the masses of adenoid tissue which, as I have already said, are to be found even in the healthy liver in the portal canals.

As regards the general structural character of the changes which are produced in the liver by the tuberculous infection, I have nothing to add to my former statements. They have been since described by Dr. Petroff and by Dr. Fox, whose accounts agree in all essential respects with my own. The chief change, says Dr. Fox, "is the appearance "of a tissue of a glistening, semi-transparent character, which occupies "the substance of the organ to a variable extent. Sometimes it only occurs "in little specks of the size of a pin's head or a poppy seed; sometimes "it is in larger masses; sometimes it runs in lines, mapping out the "acini very distinctly; sometimes it is found in irregular masses in "which there is no trace of liver structure visible to the naked eye; "or the conditions before described may be reversed, and remains of "natural-looking liver tissue may be seen running in lines irregularly "through the semi-transparent tissue."† The observations of Dr. A. Petroff,‡ although short, are comprehensive and very clearly expressed. He differs from Dr. Fox and myself only in one particular, namely, in stating that although the new growth, as a rule, originates from the inter-lobular spaces, distinct masses of it are sometimes found either around the intra-lobular veins or even in the substance of an acinus, which are not continuous with the larger layers or masses by which the lobules are separated from each other.

There being, therefore, a complete concurrence of observation as to the general features of the process, we are in a position to proceed to

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* MacGillavry, Zur Anatomie der Leber, Sitzungsbr. der Wiener Akad. 1864, Bd. l. p. 207.

† Fox, loc. cit. p. 12.

‡ Dr. A. Petroff, Prof. in Kasan, Zur Impfbarkeit der Tuberculose Virch. Archiv. B. xliv. S. 129.

the examination of the other questions which suggested themselves at the close of my last year's inquiry; as, for example,

1. From what normal structure does the cellular reticulum, which at first constitutes the whole of the new growth, originate?

2. What is the ultimate destiny of the diseased parts?

I propose to consider each of these in succession.

Relation of the new Growth to existing Structures.—In the liver, as in the lymphatic glands, different parts of the same organ are always found to be in different stages of alteration. Thus at an early period, as, for example, six weeks after infection, the only changes which can be discovered by the naked eye consist in general enlargement and unnatural paleness of the whole organ, with granulations, masses, or laminæ of transparent material scattered through its substance. But on minute examination, even of the most healthy parts of such a liver, important structural alterations are discovered, both in the acini themselves and in the inter-lobular tissue. In cross sections of the inter-lobular spaces, *e.g.*, sections made near the surface in planes parallel to that of the capsule, it is seen that the inter-lobular vessels and ducts, instead of being in immediate contact with the peripheral ends of the columns, are sheathed in adenoid reticulum. The meshes of this reticulum are in some parts so minute as to contain only single lymph corpuscles (Plate IV., Fig. 4,) while in others they are of various sizes. The larger spaces contain veins or arteries (lymphatics?) and ducts. The smaller enclose masses of lymphoid corpuscles, the position and relations of which may be correctly stated by saying that they and the fine reticulum by which they are held together, fill up all the space not occupied by the vascular structures above mentioned. In pencilled sections these masses are apt to be removed altogether, so that the network which occupies the portal canal appears much coarser than in its original condition. (See Plate VI., Fig. 3.) The portal veins and arteries are unaltered, but it is constantly observed that the ducts, and especially those that are in immediate relation with liver cells, are enlarged, and that their epithelium has lost its regularity of arrangement. From the examination of a great number of similar sections, I infer that in the inter-lobular spaces the disease begins as an overgrowth of the normal adenoid pulp of the portal canals. In the acini the first change observed is a remarkable one. It consists in dilatation of the radiating capillary blood channels and in the appearance of corpuscles in great number within these channels, many of which cannot be distinguished from the colourless corpuscles of the blood, while others differ from them both in size and appearance. They measure from $\frac{1}{4000}''$ to $\frac{1}{1200}''$; the larger are nucleated, the smaller might be described as themselves nuclei. (See Plate III., Fig. 4, and Plate VI., Fig. 4.) Here and there they collect in great numbers, so as to choke up the vessel in which they appear to be contained. They differ mainly in their variability of size from the corpuscles of the reticulum, which seldom exceed $\frac{1}{3000}''$ in diameter. These appearances clearly admit of two interpretations. It may be supposed, either that the bodies in question are in reality what they seem to be, or that they are corpuscles which have originated in the vascular sheath, and have grown into the capillaries. It is not possible to determine by direct observation which of these views is the true one.

As a strong ground for believing that the bodies in question are inside of the capillaries, it is to be borne in mind that the existence of large numbers of colourless corpuscles in the blood vessels leading from adventitious adenoid tissue, is a condition which has been already met with in our study of the omentum; and further, that in all probability the spleen during its first stage of morbid overgrowth delivers

into the portal circulation many more colourless blood corpuscles than in its natural condition. The large size of the corpuscles seems to me to tell as much against the one view as the other; for in this respect they differ as completely from the colourless corpuscles of the blood as from those of the adenoid reticulum. Whatever may be the origin of these bodies, it is certain that their presence must conduce, with other causes to be immediately mentioned, to obstruct the intra-lobular circulation ; for it is constantly observed that the vessels in which they are found are either obliterated or plugged with blood discs.

The eventual result of the morbid process is the conversion of the whole organ into a mass of semi-transparent aspect, which resembles both in consistence and structure a lymphatic gland in advanced fibrous degeneration. The steps which lead to this result are as follows :—We have already seen how all the tubular organs in the portal canals lie in a network of transparent intermediary substance continuous with that which forms the adenoid reticulum, and that in an early stage of disease this network becomes coarser and more distinct. It is very difficult to trace this structure into the acini, so long as their condition is unaltered; but in preparations of the kind represented in Plate III., Fig. 1, in which the intra-lobular vascular network is freed from the liver cells by pencilling, I have always found that bands or strings of hyaline substance bridge over the interspaces between the capillaries at distances which evidently correspond to the width of the liver cells ; so that from my own observation I am inclined to concur with those who believe that the organ is pervaded throughout by a framework of hyaline bands, which has the same relation both to the capillaries and to the cellular elements of the organ as that which exists between the corresponding structures in the lymphatic glands. Whatever conclusion we may arrive at as to the presence of the so-called *tela conjunctiva* in the healthy organ, there is no doubt that as soon as the tissue of a lobule becomes affected by tuberculous disease, the existence of such a framework becomes obvious ; and that the first change by which the encroachment of the inter-lobular new growth of the glandular tissue is indicated consists in the development of transparent bands or threads, in the interlacing of which the capillaries and liver cells gradually become involved. The arrangement of these bands is such, that in proportion as they become thicker and stronger the affected tissue is converted into a fibrous looking meshwork, in the holes of which the original elements are imprisoned. In this way the liver cells become broken up into masses which are separated from each other by septa of transparent material. Hence two results follow—on the one hand the capillaries collapse and lose themselves in the trabeculæ of the newly formed stroma, while on the other the liver cells, which at first struggle for existence with adventitious cellular elements in the loculi of the stroma, finally waste away, the nucleus often remaining after the body of the cell has disappeared.

Simultaneously with this change the terminal bile ducts become the seat of another and most remarkable alteration. In all specimens in which the diseased process is far advanced, certain spots are to be observed in the sections which are distinguished by their extreme transparency, not merely from those parts in which the liver cells are still in situ, but from the general mass of diseased tissue of which they form a part. The transparency of these spots is found to be due to the fact that the loculi, instead of containing liver cells or the remains of their disintegration, are occupied by bile-duct epithelium. In comparing them with sections of normal bile ducts it is found that the form and measurement of the cells are identical, and that they differ in nothing excepting the irregular

size and contour of the loculi themselves, and the absence of any arrangement in their contents. The only other view which can be entertained of their nature is that they are liver cells which have lost their granular contents, retaining their nuclei; in favour of which it is to be noticed that loculi are often to be found which are partly filled with liver cells and partly with epithelial cells. (See Plate III., Fig. 3.)

The final stage of the process is easily described. All cellular elements disappear excepting a few scattered lymph corpuscles. What remains is a fibrous network in the arrangement of which that of the tissue which it has supplanted may still be traced. In other respects it resembles the corresponding structures which we have already studied in the spleen and lymphatic glands (Plate VI., Fig. 4). Thus it appears that the adventitious adenoid pulp of the liver is liable to a process of fibroid degeneration which corresponds in all its important features to that which affects the natural tissue in those organs of which it forms the essential constituent.

Additional Observations as to Tuberculosis of the Lungs.

In the lungs the lesions are so uniform in their character in all the animals I have examined that I have nothing to add to the general description given last year, and shall confine myself to those questions which were then left undecided, and to others which arise out of observations made since. These refer to the relations of the adventitious masses of adenoid pulp which were designated in my last report peribronchial granulations, with those which exist normally in the lung, as well as to the irongrey nodules.

Considering that these granulations occupy the same position and have the same structure as the normal ones, differing from them only in size, it is natural to conclude that the relation between diseased and healthy structure is the same in the lungs as we have already found it to be in the peritonæum. As to the significance of the semi-transparent nodules which have been so often compared to miliary tubercles, repeated observations have shown me that the structure represented in my fourth figure (see former Report) is uniformly met with in microscopical sections of these bodies; and that in fact the semi-transparent nodules are not so analogous to miliary tubercles as to blocks of lobular catarrhal pneumonia. They owe their transparency not to the structural elements of tubercle, but to cells identical in size and appearance with the natural alveolar cells of the lung. In order to understand the nature of the pathological process of which these nodules are the expression, the manifestations of disease must be studied separately in each element of the original tissue, *i.e.*, in the alveolar cells, the alveolar and bronchial epithelium, the blood vessels and lymphatics.

The alveolar cells are nucleated bodies which are always to be found in the alveolar cavities of the healthy lung. Each probably consists of a solid envelope of transparent substance collected round a more refractive central part. They usually contain a good many granules of black pigment, which are embedded in the envelope along with other granules of different chemical constitution. When seen in the healthy injected lung they look as if they filled the spaces between the network of capillaries which covers the internal surface of each alveolus. This arrangement, although it is, I believe, quite accidental, has led to their being often described as epithelium, in consequence of which much confusion has been introduced into the subject. The true alveolar epithelium is very difficult to demonstrate. Its elements are much smaller than those

above described, and correspond in structure and arrangement with those of the terminal bronchial tubes. The latter can be readily studied in sections recently prepared by v. Recklinghausen's method. In such sections the epithelium may either be examined *in situ*, or may be prepared separately. It consists of oval or oblong plates (Plate V., Fig. 4), each of which contains a spherical nucleus about half as wide as itself. As the epithelium nuclei are readily stained by neutral solution of carmine, the bronchial epithelium, when so stained resembles a collection of lymph corpuscles, and when seen in double layer may be easily mistaken for a granulation, for which reason carmine staining is rather a hindrance than a help in studying diseased lungs. On tracing this terminal epithelium into the lobule into which the bronchiole leads, it is seen to fade away gradually till it becomes imperceptible, the reason apparently being that it is so exceedingly delicate that it is destroyed by any of the ordinary liquids used under the microscope. That the epithelium really does extend into the alveoli themselves without materially changing its form, has I think been satisfactorily demonstrated by Chrzonszczewsky.*

In the alveolar walls of the healthy uninjected lung no structure can be distinguished excepting the delicate elastic framework of fibres by which the septa are supported. But in the diseased parts these septa are thickened in a way which I described last year as analogous to the thickening of the trabeculæ of the spleen and lymphatic glands by the interstitial growth of nucleated cells. That the irongrey nodules do not consist entirely of alveolar cells may be readily proved by applying the process of pencilling to microscopical sections made parallel to the surface. By this means all the alveolar cells may be worked out, while the parietal cells are retained in their place by the connective substance of the septum in which they originate and are embedded.

In animals killed at an early stage of tuberculosis, that is to say, about four weeks after inoculation with tuberculous matter, no change is observed excepting that the peribronchial adenoid pulp is increased, or in other words, that true miliary granulations are formed in the neighbourhood of the terminal bronchioles. This fact appears to afford the key to the mode in which the irongrey nodules are produced. Whether the choking up of the air cells is a merely mechanical result of the accumulation of adventitious matter around the bronchioles or of a catarrhal process, there can, I think, be little doubt that the granulation stands to the block of lobular pneumonia in the relation of cause to effect, and that when a kernel of adenoid pulp occupies the centre of a nodule the fact signifies that the nodule originated from it.

We have, lastly, to consider the relation of the process to the absorbent vessels. It has been long known that the lymphatics of the lungs may be divided into a superficial and a deep system of vessels. In the dog† the superficial lymphatics spread over the whole surface of the organ in the form of a network, the vessels following the divisions between the lobules. From this network the lymph finds its way, by vessels which sink into the depth of the lung along with veins, and then accompany the bronchial tubes to their origin. In this course the lymphatics form more or less perfect sheaths around the blood vessels and bronchi. When the lymphatics of the lung are injected

* Chrzonszczewsky, Ueber das Epithel. der Lungenbläschen der Säugethiere, Würzburger Med. Ztscht. Bd. iv. p. 206.

† Wywodzoff, Die Lymphwege der Lunge, Wiener Med. Jahrbücher, Bd. xi. p. 1, 1866.

APPENDIX. — *On the Inoculability, &c. of Tubercle, by Dr. Sanderson.*

in the dog the mass may be traced even into the septa of the alveoli. From the alveoli the lymphatic channels converge so as to form larger vessels, which commence in the immediate neighbourhood of the bronchioles and terminal arterioles. At these points of confluence, says Wywodzoff, collections of lymph corpuscles are always to be found, which he supposes to be contained within the lymphatic cavity. However this may be, the fact is of great interest as showing the close relation between these masses and the absorbents. The observations of Wywodzoff relate entirely to the pulmonary lymphatic system of the dog. It has been shown by Afonassiew,* that if carmine is injected into the pleura of the living guinea-pig, the liquid finds its way into the deep lymphatics which accompany and surround the lymphatic tubes, the course of which is indicated by the staining of the tissue; so that there is every reason to believe that the superficial system of absorbents communicates with the deep system in the same way in the rodents as in the dog.

CONCLUSIONS.

1. The characteristic product of tuberculosis is not an aggregation of shrivelled particles of irregular form, but a tissue composed of lymph corpuscles held together by a network of hyaline connective substance.

2. There is a close structural analogy between this tissue and that of certain follicular organs belonging to the lymphatic system, *e.g.*, the follicles of Peyer, the ampullæ of the lymphatic glands, &c.

3. All the favourite seats of tubercle are naturally characterized by the presence of this tissue, which, from the analogy stated above, may properly be called *adenoid.*†

4. The natural distribution of adenoid tissue in the body is in intimate relation with the lymphatic system. In the great serous membranes (which v. Recklinghausen's discoveries have taught us to regard as walls of lymphatic reservoirs) it forms sheaths round the blood-vessels, or masses of microscopical dimensions and irregular contour underneath the epithelium. In the solid viscera it is distributed here and there in the course of the lymphatic channels.

5. In the peritonæum, tuberculosis primarily consists in the enlargement or overgrowth of these sheaths or microscopical masses of adenoid tissue, and consequently the tuberculous nodules which are formed have the same intimate structure, and stand in the same anatomical relation to the vessels and epithelium. In the viscera the essential lesions also consist, not in new growth, but in overgrowth of pre-existing masses of adenoid tissue.

6. The primary local lesion in artificial tuberculosis, whether the cause be simple wound or specific inoculation, consists in the development at the seat of injury of granulations or nodules which have similar structural characters with those of adenoid tissue elsewhere, but cannot as yet be shown to be in relation with the absorbent vessels.

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* Afonassiew, Ueber den Anfang der Lymphgefässe in den serösen Häuten, Virch. Arch. Bd. xliv. p. 37.

† The term adenoid has been introduced into pathological nomenclature in an entirely different sense. It has been applied to tumours which consist essentially in overgrowth of elements belonging not to adenoid, but to acinous glands, *e.g.*, of the epithelium of the liver and breast respectively.

7. The first step in the dissemination of tubercle, consists in its being absorbed primarily by the lymphatics (which convey it to the lymphatic glands of which they are tributaries), and secondarily by the veins. Having thus entered the systemic circulation, it is distributed universally by the arteries. The serous membranes seem, however, by preference to appropriate it, and from them it extends by contiguity to the superficial parts of the organs which they cover.

8. The final stage of the process consists in the tertiary infection of the glands of each diseased organ, which glands consequently undergo enlargement and induration, and eventually become partially caseous. The enlargement is due to the multiplication of cells in all the tissues of the organ, but more particularly in the alveoli—the hardening to a process of fibrous degeneration—while the caseation consists in slow necrosis of the previously hardened and anæmic parts. From the first the gland is incapable of performing its functions, but it is not until induration commences that the absorbents of the organ to which it belongs are completely obstructed.

9. In the liver of the guinea-pig, and in some other organs, tuberculous tissue undergoes a fibroid degeneration and caseation, the results of which cannot be distinguished from those observed in the normal adenoid tissue of the lymphatic glands and of the spleen.

10. As regards the question of a specific contagium of tubercle, we think it very important to note that this is not as yet disproved by the facts of traumatic tuberculosis. It still remains open to inquiry whether or not injuries which are of such a nature that air is completely excluded from contact with the injured part are capable of originating a tuberculous process. The results of the following experiments undertaken at the instance of Mr. Simon, with special reference to this question, seem indeed to suggest that they may not be so. Setons steeped in carbolic acid were inserted in 10 guinea-pigs on the 24th of September 1868, each animal receiving two. At the same time extensive fractures of both scapulæ were produced on five others, care being taken not to injure the integuments. No tuberculosis or other disease of internal organs resulted in either case. These facts certainly point to the necessity of further investigation in this direction.

Explanation of Plate I.*

Fig. 1. A knot of capillaries from the peritonæum in the neighbourhood of the pancreas. *a.* Arteriole. *b.* Vein. *c.* Mass of lymph corpuscles in which the capillaries are embedded. *d.* Network of omentum. From a healthy guinea-pig; the vessels have been filled with carmine by Chrzonszczewsky's method. Magnified 460 diam.

Fig. 2. An artery partly surrounded by a vascular, adenoid sheath; from the same preparation as Fig. 1. The large connective tissue corpuscles (*a.a.*) stained with carmine differ from lymph corpuscles principally in size. They present the appearance of round or oval masses in which neither granules nor nuclei can be discovered. Magnified 650 diam.

Fig. 3. A vein and artery from the same preparation. The vein is filled with colourless blood corpuscles or lymph corpuscles, some of which are stained, while others remain of their natural colour. Magnified 650 diam.

Fig. 4. Mass of adenoid tissue surrounding capillary loop; the smaller vessel can be traced directly from an artery, the larger opens into a vein. Magnified 460 diam.

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* All the figures on Plates I.—VII. were drawn by the artist from the microscope, with the aid of the "neutral tint reflector." Those on Plate VIII. were drawn by myself with the drawing prism.

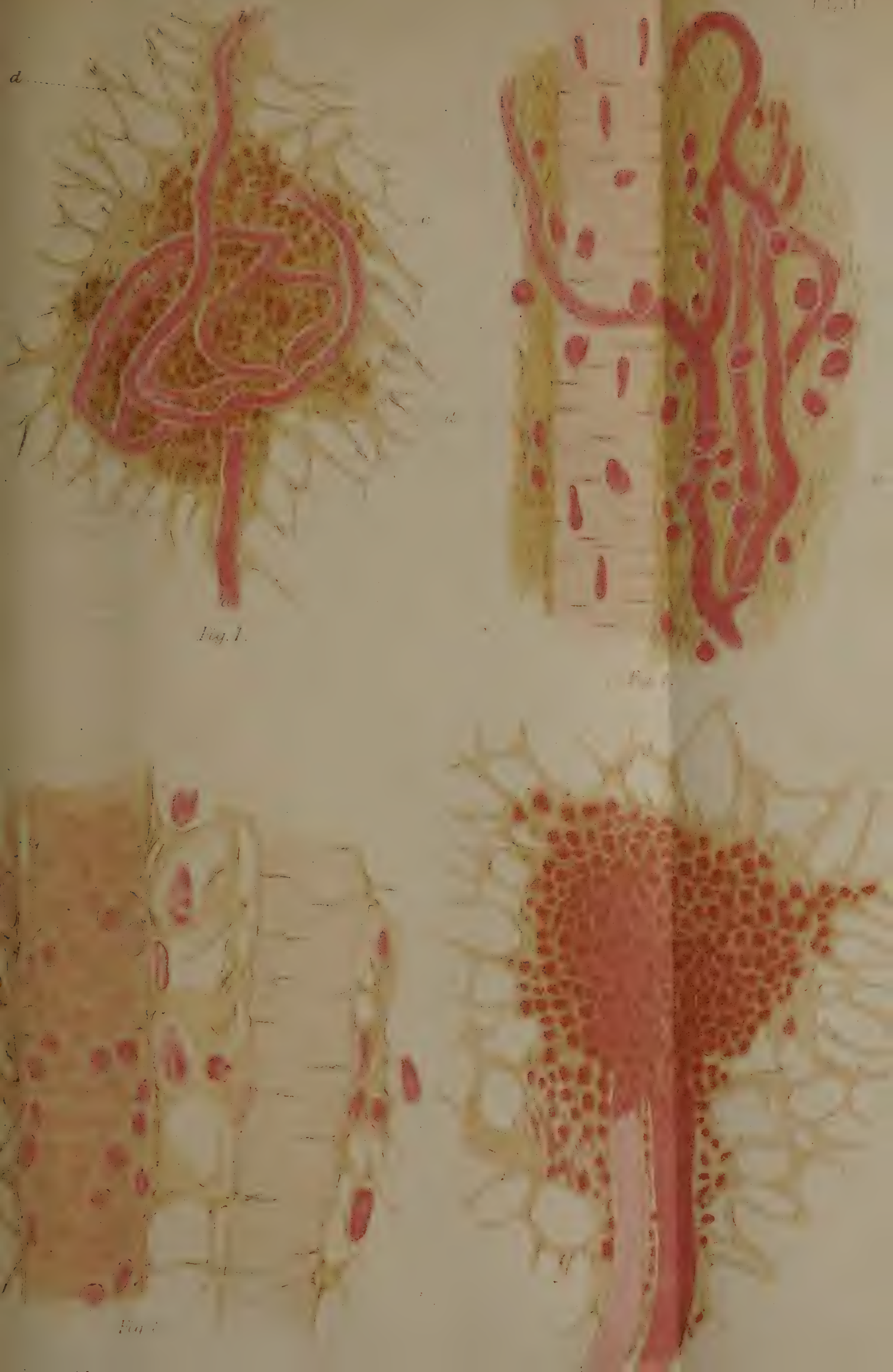


Fig. 1.

Fig. 2.

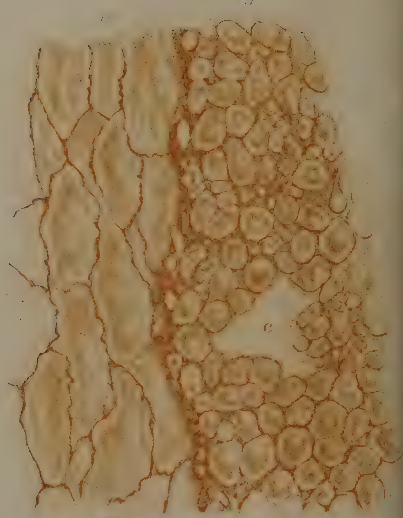


Fig. 4.

Explanation of Plate II.

Fig. 1. Part of a vascular anastomosis from the peritonæal fold enclosing the pancreas, from a tuberculized guinea pig. The drawing shows the relation between the tuberculous nodules and the larger vessels of the peritonæum. The vessels occupy the axis of a cylindrical sheath in which two kinds of tissue can be distinguished, viz.: an adenoid layer externally and fat cells internally. The nodules, which are of extreme transparency, are outgrowths from the adenoid part of the sheath. *a.a.* Nodules. *b.* Peritonæal membrane. Magnified 7 diam.

Fig. 2. Part of vascular sheath from the same preparation magnified 100 diam. *a.* External adenoid layer. *b.* Internal adipose tissue.

Fig. 3. Aggregation of lymphoid corpuscles underneath the peritonæal epithelium in a healthy animal. *a.a.* Network of omentum. *b.* Nuclei of epithelium. Magnified 650 diam.

Fig. 4. Epithelium of healthy omentum, prepared by v. Recklinghausen's method. *a.a.* Epithelium covering an artery and vein. *b.b.* Epithelium covering the adenoid sheath. At *c.* the epithelium is deficient. Magnified 650 diam.

Fig. 5. Epithelium covering a tuberculous nodule. Magnified 650 diam.

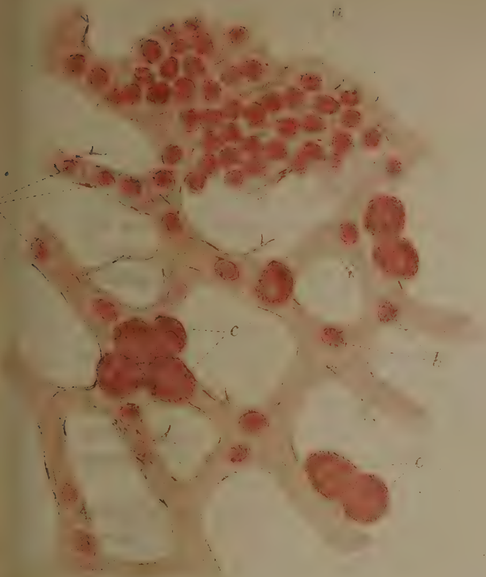
Explanation of Plate III.

Fig. 1. Tela conjunctiva of the human liver. *a.* Granulation of adenoid tissue. *b.b.* Nuclei embedded in the sheaths of the capillaries. *c.c.* Liver cells, most of which have been removed from the framework by pencilling. (From a case of general lymphoma communicated to the Pathological Society by Dr. Murchison). Magnified 460 diam.

Fig. 2. Reticulum of liver of guinea-pig in early stage of tuberculosis. *b.* and *c.* as in Fig. 1, magnified 460 diam. The two drawings are intended to illustrate the mode in which overgrowth of lymph corpuscles commences in the sheaths of the capillaries of the acini, which sheaths collectively constitute what is called the tela conjunctiva. They further show the anatomical correspondence between lymphoma and tuberculosis.

Fig. 3. Liver of guinea-pig, No. 56, (2d series). *a.* Vascular spaces containing lymph corpuscles and coloured blood corpuscles. *b.* Liver cells. *c.* Reticulum. *d.* Nuclei of epithelium contained in dilated bile ducts. Magnified 460 diam.

Fig. 4. Section of the same liver in an earlier stage of alteration. *a.* Vascular spaces. Many of the lymph corpuscles are of large size and nucleated. *b.* Liver cells. Magnified 460 diam.



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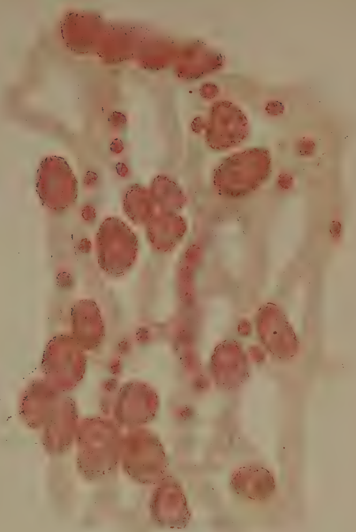

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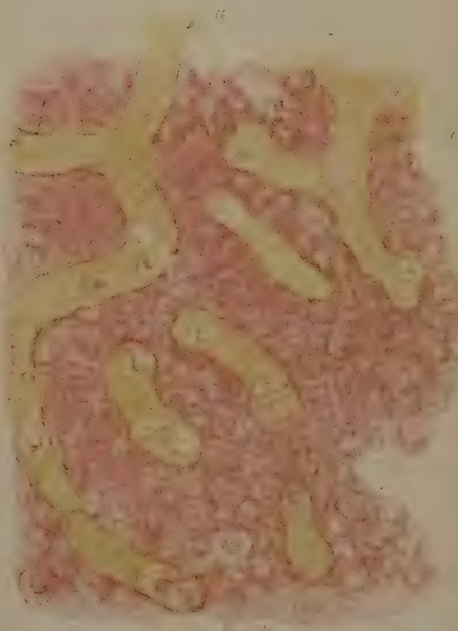

Fig. 4.

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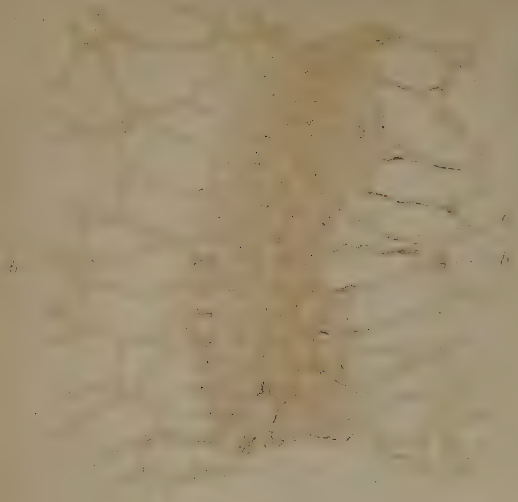

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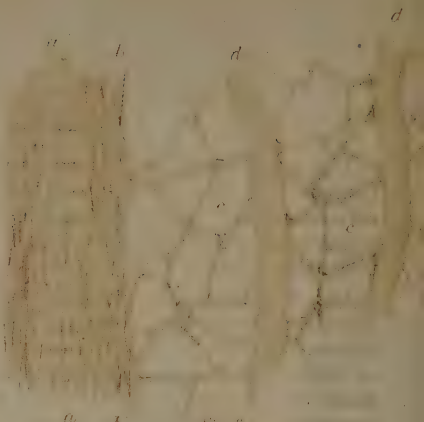

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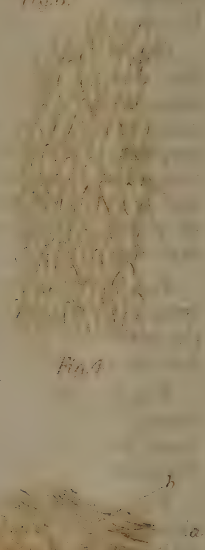

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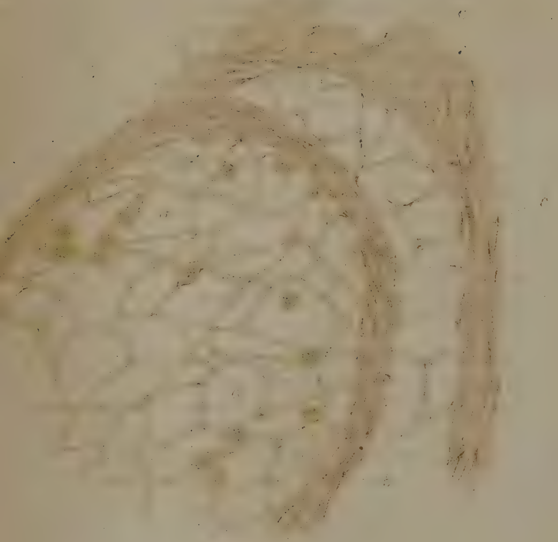

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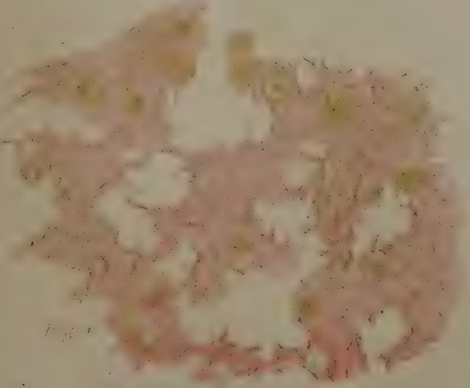

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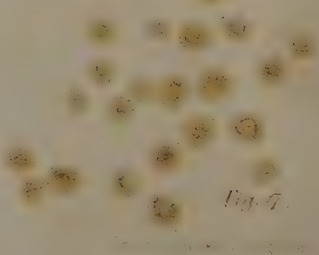

Fig. 7.

Explanation of Plate IV.

Fig. 1. A medullary cylinder of a healthy lymphatic gland. *a* Cylinder of adenoid tissue in the meshes of which numerous lymph corpuscles are embedded. *b*. Coarser network of lymph sinus from which the lymph corpuscles have been removed by pencilling. Magnified 650 diam.

Fig. 2. Summit or extremity of an ampulla. *a*. Reticulum of the ampulla. *b*. Limiting membrane of the ampulla, the structure of which differs from that of the reticulum only in the closeness of the filaments of which it consists. *c*. The lymph space. *d*. Fibrous connective tissue which forms the cortical substance of the gland. With the exception of the few lymph corpuscles shown, all have been removed by pencilling. Magnified 460 diam.

Fig. 3. Portion of the same ampulla. The figure is intended to show the relation between the reticulum and the vessels. *a*. Artery, the structure of which is seen indistinctly through the sheath of closely woven connective tissue which covers it. *b.b*. Limiting membrane of the ampulla, the structure of which is continuous with that of the sheath of the artery. *c.c*. Reticulum of the ampulla, from the meshes of which the lymph cells have been pencilled out. *d.d*. Capillaries, the sheaths of which are united with the filaments of the reticulum. Magnified 460 diam.

Fig. 4. Reticulum adjoining an interlobular bile duct from which the lymph corpuscules have been removed by pencilling. The meshes of the reticulum are oval, their long axes being in the same direction as the bile duct and the vessels accompanying it. Magnified 460 diam.

Fig. 5. Cross section of four bile ducts, surrounded with adenoid tissue, from the reticulum of which almost all the lymph corpuscles have been pencilled out. *a.a*. Bile duct epithelium. *b*. Reticulum. Magnified 460 diam.

Fig. 6. Adenoid tissue in the neighbourhood of a minute branch of the hepatic artery. (From a liver in advanced fibroid degeneration in which the hepatic artery has been injected.)—The reticulum is transformed into a sponge-like tissue in which laminæ take the place of filaments. Lymph corpuscles, many of which are nucleated occupy some of the loculi. Magnified 460 diam.

Fig. 7. Lymph corpuscles from blood of portal vein of guinea-pig, No. 56, (2d series). Magnified 460 diam.

Explanation of Plate V.

Fig 1. Nodular tubercular overgrowth of adenoid vascular sheath from the omentum of a tuberculized guinea-pig, killed four months after inoculation. The abdominal organs have been injected with Beale's blue, by the cœliac axis. The preparation demonstrates the extreme vascularity of tuberculous new growth. The capillaries of new adenoid tissue being of great delicacy, they cannot be made out without injection. In the present instance the injection had passed into the veins, many of which were slightly coloured. Magnified 460 diam.

Fig. 2. Section of a pulmonary lobe of a healthy guinea-pig procured for the purpose of demonstrating that adenoid tissue, indistinguishable from that which constitutes tubercular granulations, exists in the normal lung. The section has been made so as to cut across the principal artery and bronchus of the lobe. *a*, artery ; *b*, bronchus—the brownish red bodies being imperfect cartilaginous rings ; *c*, mass of adenoid tissue surrounded by a layer of black pigment. This mass is cylindrical, the axis of the cylinder being parallel to that of the bronchus and artery, to which structures its relative position is always as represented ; *d*, alveolar tissue ; *e*, loose connective tissue surrounding the artery and bronchus. Magnified 60 diam.

Fig. 3. Apparently healthy lung of guinea-pig, No. 94, (2d series) inoculated three weeks previously by introducing tuberculous material into the peritonæum. The lung was first injected with Prussian blue by the pulmonary artery, and then filled to distension with warm solution of gelatine. In fresh sections stained with carmine of the lung solidified in this way, microscopical collections of lymph corpuscles (*a*) could be discovered here and there, all of which were in close proximity to small arteries or bronchioles. In the drawing a "granulation" of this kind is seen lying behind a minute arterial trunk which the knife has happened to truncate immediately in front of the centre of the little mass. Its rounded form is evidently due to its having grown into an alveolar cavity, the capillaries of which may be traced over it. The rich capillary network (*b*) which surrounds it belongs to other adjoining alveoli. Magnified 200 diam.

Fig. 4. Shred of epithelium from an infundibulum, stained with nitrate of silver. This epithelium does not cease abruptly where the internal surface of the infundibulum becomes continuous with that of the alveoli, but gradually loses its distinctness. I have failed in my endeavours to demonstrate an epithelial layer in the alveoli, but do not doubt its existence. Magnified 650 diam.

Pl. V

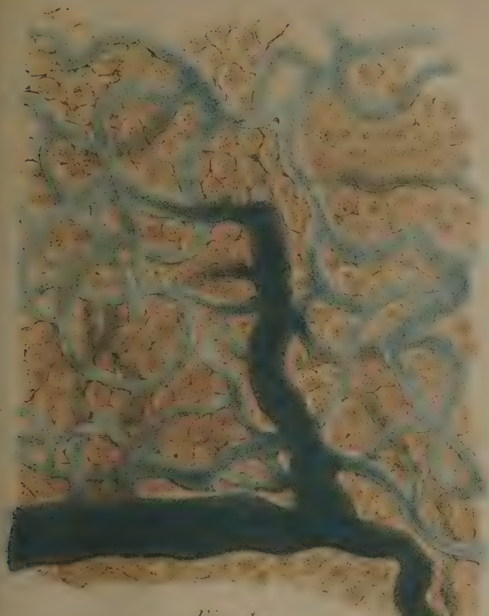

Fig. 1.

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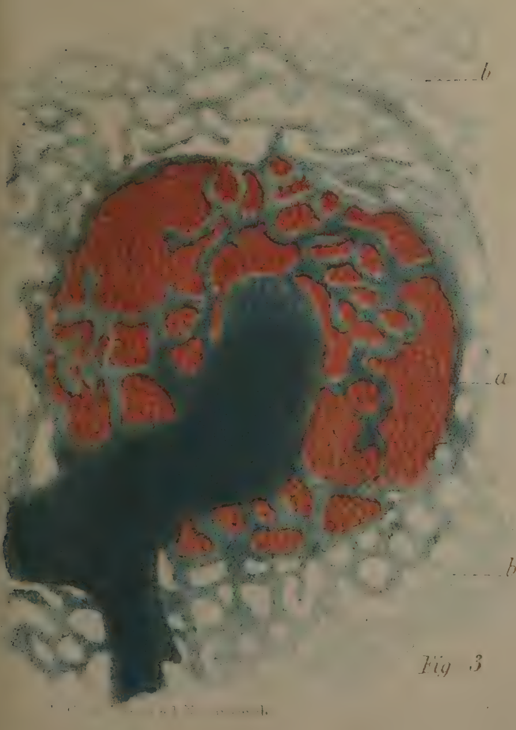

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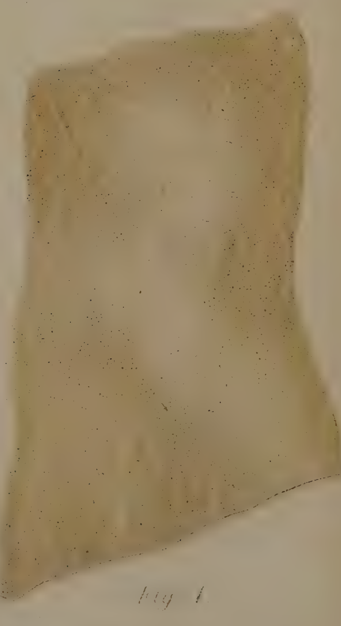

Fig 4

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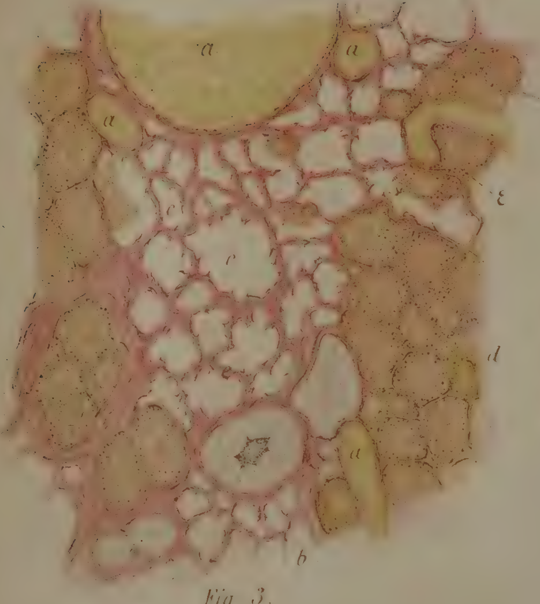

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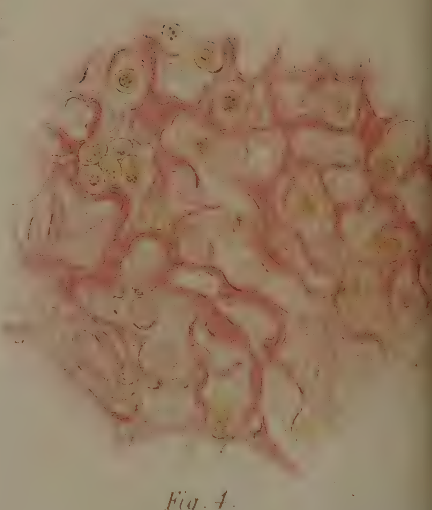

Fig. 4.

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Explanation of Plate VI.

Fig. 1. Section of liver of guinea-pig, No. 56, (2d series), inoculated 29 weeks before death with transparent material from the supra renal capsule of a patient who had died on the previous day of Addison's disease. The section is vertical to the surface of the organ. *a.a.a.* Interlobular bile ducts lined with epithelium. *b.b.* Ends of the converging columns of liver cells of which an acinus is formed. *c.* Reticulum from the meshes of which the corpuscles originally occupying them have been removed by pencilling. From the obliquity of the plane of section in relation to the interlobular septum, some parts of it appear fibrous, others alveolar. Magnified 460 times.

Fig. 2. Epithelium of the double layer of peritonæum which encloses the extremity of the pancreas of the guinea-pig ; the drawing is intended to show the structure of this membrane, in relation to the frequency with which it becomes the seat of tubercular granulation. *a.* Nuclei of the epithelium, some belonging to the layer nearest the observer others to the layer opposed to it. The reticulated wavy lines represent the interstitial cement by which the contiguous elements (scales) are united to each other. Those which intersect each other belong to different layers. The epithelium where it covers the vein (*v.v.*) is modified in form, the scales being oval or oblong. *b.* Apertures in the membrane at the edges of which the two layers of epithelium are continuous with each other. Everywhere else the space between the two layers is occupied either by vessels or by a meshwork of extremely delicate connective tissue fibres, which are continuous with the similar tissue which forms the sheaths of the blood-vessels. This tissue is of such tenuity that even in preparations stained with carmine, it is not distinguishable, unless the epithelium has been removed by previous maceration. The lymphoid corpuscles which exist in such numbers in certain parts of the same membrane are embedded and originate in this structure.

Fig. 3. Section of liver of guinea-pig inoculated four months previously by Dr. Fox with human tubercle. The section is parallel and near to the surface of the organ. *a.* Portal vein and tributaries thereto. *b.* Section of an interlobular duct. *c.* Reticulum occupying the greater part of the portal canal. *d.* Cavity containing remains of epithelium. As in fig. 1, the cells which originally filled the holes of the reticulum have been removed by pencilling. Some have contained adenoid pulp, others liver cells (*e.*) Magnified 460 times.

Fig. 4. Pencilled section of acinous tissue of liver in advanced fibroid degeneration. The reticulum is so abundant, that it seems to constitute the whole substance of the organ. The liver cells as well as the adenoid pulp have entirely disappeared ; of the cellular forms that remain some probably are epithelial nuclei, others which appear to be contained in vascular cavities, are I believe of the same nature as the corpuscles met with in the earlier stages of the process in the capillaries. Magnified 460 times.

Explanation of Plate VII.

Fig. 1. Vertical section of capsule of spleen of guinea-pig, No. 56 (2nd series). *a.* External surface of capsule, the epithelium being removed in making the section. *b.* Commencement of a splenic trabecula. *c.* Adenoid tissue forming a sub-peritonæal granulation, the structure of which is continuous with and indistinguishable from that of the capsule of the organ. *d.* Section of a vein. The margin at *e.* corresponds to the position originally occupied by a malpighian follicle, the structure of which can no longer be distinguished. A line connecting the two asterisks would correspond to the natural direction of the capsule. All that lies to the right of it may be regarded as new growth. Magnified 460 diam.

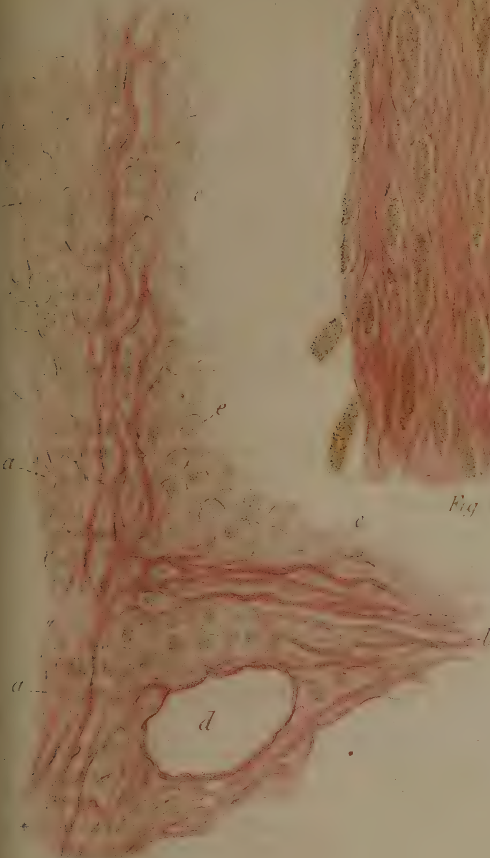
Fig. 2. Section of a new growth occupying the connective tissue adjacent to the tendon of the transversalis abdominis and in the immediate neighbourhood of the inoculation wound; from guinea-pig, No. 94, three weeks after inoculation. Magnified 650 diam.

Fig. 3. Section of a sub-cutaneous nodule of adenoid tissue in close proximity to the inoculation wound, three weeks after inoculation. The plane of section is parallel to the surface of the skin. Magnified 460 diam.

Fig 4. Section of the same nodule in the opposite direction. *a. b. c. d.* Nucleated cells much larger than the ordinary lymph corpuscles, which are met with here and there in the meshes of the stroma. Magnified 460 diam.

Fig. 5. Vertical section of capsule of spleen in advanced fibroid degeneration. All the cells have disappeared, while the fibroid bands have increased remarkably in thickness. The deeply coloured mass shown in the upper part of the drawing consists of the same hyaline structureless material of which the fibroid bands are composed. Similar masses are met with throughout the diseased organ, sections of which when stained with carmine appear when viewed with a lens to be scattered with red points. No trace of cells or nuclei can be distinguished either in the bands or masses. Magnified 460 diam.

Fig. 6. Section of the hilus tissue of a lymphatic gland in a similar condition of induration. *a.* A minute artery surrounded by a loculous hyaline stroma, containing a few lymph corpuscles. Magnified 460 diam.



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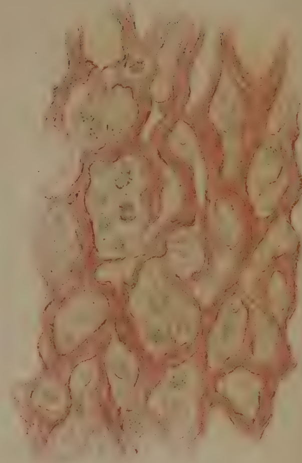

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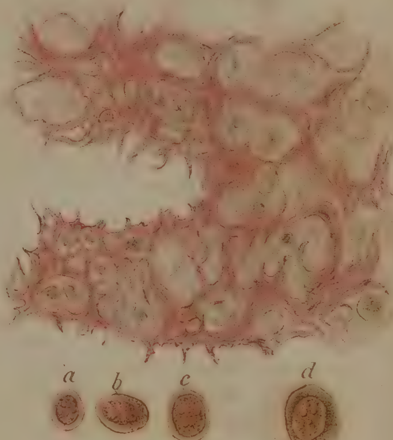

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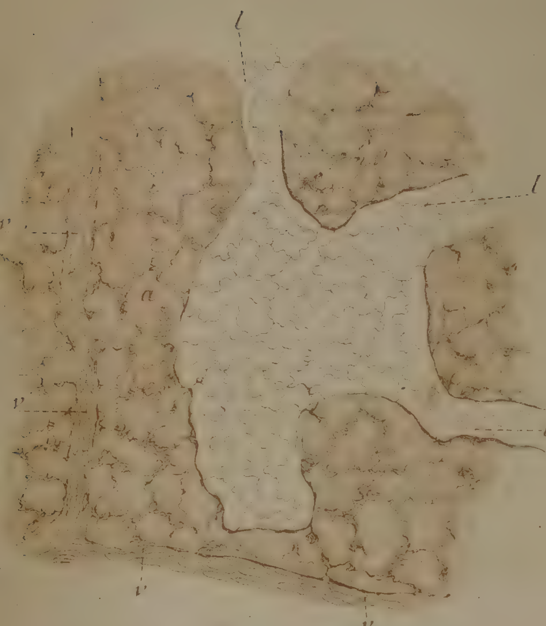

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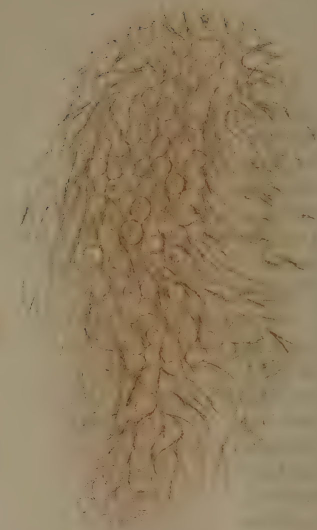

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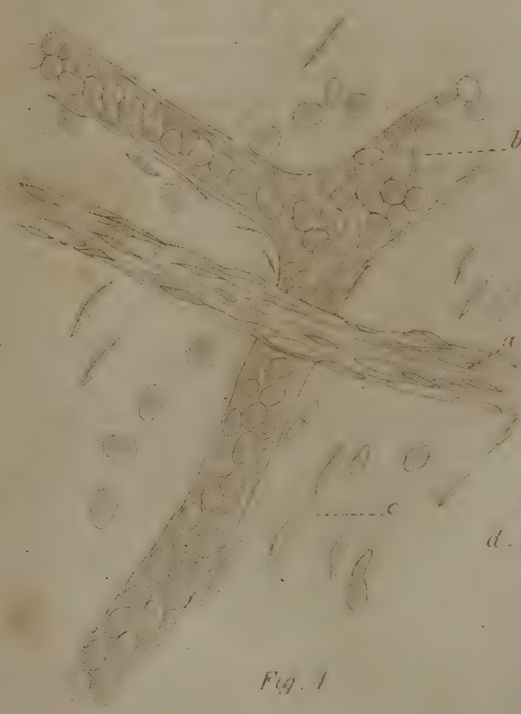


Fig. 4

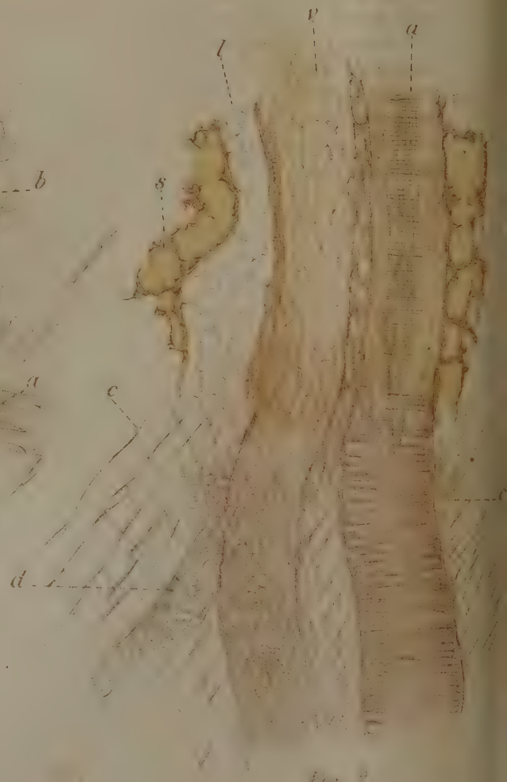


Fig. 2

Explanation of Plate VIII.

Fig. 1. A lymphatic lacuna from the peritonæal surface of the diaphragm. *v.v.* Veins. *l.l.* Lymphatics. The dark lines which ramify in the spaces between the vessels are the so-called sap canals of v. Recklinghausen. Near *a.* the limiting membrane of the lacuna seems to be imperfect. By altering the focal adjustment, the layer of epithelium which covers the deep surface of the lacuna can be brought into view. The superficial layer appears to lie immediately underneath the peritonæal epithelium, which has here been removed by maceration. Magnified 207 diam.

Fig. 2. Artery and vein, with accompanying lymphatic channel, lying immediately under the peritonæal epithelium. In the upper part of the preparation, the vascular structures, and sap canals are stained, but the staining has accidentally failed in the lower part. It is there seen that the vein is covered with an interrupted layer of lymph corpuscles, of which there is no trace in the neighbourhood of the artery. *a.* Artery. *v.* Vein. *l.* Lymphatic. *s.* Sap canals. *f.* Fibres of connective tissue which lie immediately underneath the epithelium. *c.* Inferior layer of central tendon of diaphragm. *d.* Split between two parallel tendinous bundles, into which a branch from the vein penetrates. Magnified 207 diam.

Fig. 3. Normal adenoid tissue of healthy lung from the mass represented in Plate V., Fig. 2. Magnified 490 diam.

Fig. 4. Minute artery and vein from the upper surface of the central tendon of the diaphragm of a guinea-pig, into whose peritonæum a trace of tuberculous matter had been injected three months previously. The vessels are in the immediate neighbourhood of a tuberculous nodule, the lymph corpuscles of which surround the vein. This drawing may be compared with Plate I., Fig. 3. *a.* Artery. *b.* Vein, containing numerous lymph corpuscles. *c.* Superior tendinous layer of the centrum tendineum, on the surface of which the vessels lie. Magnified 490 diam.

APPENDIX.

No. 6.
On Chemical Identification of Disease, by Dr. Thudichum.

No. 6.—FURTHER REPORT, by DR. THUDICHUM, on RESEARCHES intended to promote an improved CHEMICAL IDENTIFICATION of DISEASE.

A.—*Notes on the Febrile and some other Morbid Processes with reference to their Chemical Investigation.*

Phenomena of the febrile condition.

The febrile condition is constantly associated with the following abnormal phenomena :—(*a.*) Increased temperature of the body. (*b.*) Increased disintegration of albuminous substances. (*c.*) Diminished muscular power. (*d.*) Diminished ingestion of nutriment. (*e.*) Diminished urinary water (*f.*) Diminished powers of the senses and of the sensorium. These changes are common to all febrile states, no matter what may be their specific origin. I proceed to consider the two first conditions only, with the assistance of such chemical information as it has hitherto been possible to gather.

Temperatures in disease.

44, nerve affections.

43·37 in dying.

41·87, agony.

41·75, or death line.

41·62.

41·25 as morning T. always fatal.

50 per cent. line.

Temperatures up to C. 44° occur in certain spinal injuries and in acute tetanus. Next in order are temperatures which occur only during the process of dying, 43·37° being the absolute maximum of T. (T. = temperature) in fatal cases of typhus. At 41·87 begins the agony of death. The line 41·75 is momentous, because hitherto no patient with typhus, whose T. has risen above that line, has been known to recover. I have therefore termed this line the death-line. Patients with shivering fits in the morning may rise to 41·62 and not necessarily die ; but when typhus patients reach the temperature of 41·25 in the morning they always die. The line at 41·12 may be termed the 50 per cent. death-line, because one half of all patients going above this line die. From 41° to 40·37 range the average maxima of favourable cases, and from 40°·6 to 40° the average maxima of morning temperatures of the same class of cases, more particularly of typhus fever. At 38·6 we

come to the maximum of health, at 37·6 to the mean, at 36·76 to the minimum of health. At 36·5 we find certain cases of autumnal diarrhœa, simulating typhus and typhoid fever. This is also the death-line of cholera. All cases whose temperature ranges persistently below this line have, as far as the observations of the epidemic of 1866 went, died. The range of the minima of cholera cases is between 36·4 and 33·9, and the lowest T. observed in any case of cholera is 32·9. See tables in 9th Report, particularly Table 40.)

Morning T. of favourable cases.

36·5 is the minimum dead line of cholera.

Lowest T. observed in cholera.

In febrile and other diseases where there is no obstruction to any very great part of the circulation, the most accurate measurements are most quickly obtained in the cavities, rectum and vagina; but the same results are obtained in the axilla, if the thermometer be allowed to remain there until stationary. In some conditions, however, namely in collapse of acute cholera and in the agony of death, the temperatures of the cavities are above the temperatures of the axilla :—*i.e.*, the heat produced in the deeper tissues accumulates in them, not being carried away again by flowing blood, but having to find its way slowly through badly conducting materials. For the same reason the temperature of a body which has just died sometimes rises by several tenths or even an entire degree for some minutes, until the chemical effect of the stored oxygen is exhausted ; when, with the venous condition of the capillary blood, the local death of the tissues takes place.

Difference of T. in axilla and internal cavities.

T. rises immediately after death.

The sensation of cold in the shivering fits of high fever is a deception of the peripheral sense of temperature, produced by the contraction of the small blood vessels of the skin, and the contractile tissues of that organ in general. From the moment that this spasmodic effect ceases the fever patients have the sensation of excessive heat. Their sense of temperature is constantly excited until in delirium they fancy themselves on fire. One of the effects of this condition is that the heart makes increased efforts to circulate blood so as to obtain a compensating reduction of the temperature by increased evaporation from the lungs and skin. The number of the beats of the heart are always greatly increased in fever ; and with this increased labour the heart tends to become exhausted. A kind of artificial fever can be produced by the Turkish bath, especially with its higher temperatures. First there is sweating, then the pulse becomes rapid, and with arterial murmurs and a pulse of 140° per minute, and a rise of the temperature of the body by one or two degrees as measured in the cavities, begins a state of unconsciousness or anæsthesia, which differs entirely from syncope, with which it has been confounded, and is similar to the unconscious conditions of typhus and typhoid and other febrile patients. During this process of the production of anæsthesia by heat the powers of the muscular system are constantly decreasing, until a degree of debility equal to that of the acme of typhus is reached. Very evident in healthy persons, this effect is still more striking in persons suffering from some sorts of paralysis, with but a small amount of contractility in their muscular system left.

Nature of shivering fit.

Artificial fever by Turkish bath.

Increased disintegration of albuminous substance is the second main effect of the febrile process. Its existence and amount are ascertained by comparative analysis of the urine. It is not maintained that the non-nitrogenous matters contained in and introduced into the body during fever are not also disintegrated more rapidly. On the contrary, this is very probably the case with all, such as fat, starch, and sugar, and certainly the case with alcohol, as I have shown in the special chapter relating to that body. See last Report, p. 282. It is also certain that the quantity of non-albuminous matters disintegrated or oxydised influences the quantity of albuminous matters oxydised in the same

Increased disintegration of albuminous matters.

Appendix.

No. 6. *On Chemical Identification of Disease, by Dr. Thudichum.*

time, by diminishing it; that heat, febrile or normal, may be produced by the oxydation of either, but is produced if possible first from non-nitrogenous matters, and if these are absent or insufficient, then from nitrogenous matters.

Apparatus for collecting excretions.

In order to the accurate measurement of these effects of the febrile process the food and excretions have carefully to be ascertained and analysed; and among excretions I of course include the products of respiration. The urine has to be collected separately and completely as yielding one of the main and most important indications. In regard of persons who are not bedridden this is best done by means of special apparatus such as I described in 1864, in the Journal of the Society of Arts. And besides food and excreta, the body-weight of the patient has to be taken into consideration during the whole of the disease. All these desiderata can only be observed by the aid of particular arrangements in hospitals, and by the aid of the large and expensive apparatus first constructed at Munich by Pettenkofer and Voit. Where these facilities do not exist the research has to be limited to the determination of the disintegration of the albuminous substances. This has hitherto mainly been effected by the quantitative determination of the excreted urea by means of Liebig's volumetrical analysis. Now although this gives the main bulk of the products of disintegration, it does not indicate the whole by several per cent. Some inquirers have therefore determined the excreted nitrogen as such, by means of particular processes (Davy, Neubauer). But my researches on uromelanine, omicholine, omicholic acid, have shown that chlorine, which was relied upon as a decomposing agent in the analyses of Davy and others, does not decompose the products just mentioned in such a manner as to liberate their nitrogen, and that in short nothing but actual combustion with soda lime will set all the nitrogen of urine free in the form of ammonia. Liebig's analysis comes, however, closer up to the actual amount than the chlorine process, because urochrome is precipitated by the nitrate of protoxyde of mercury. As this amount of a compound, the nature of which is at present only partly known, enters the account as tetra mercuric-urea-nitrate, it introduces a source of inaccuracy for the elimination of which the future will have to provide. A similar remark holds good with regard to creatinine, uric and hippuric acid. But these it is possible to determine, although by difficult or circumstantial methods only. The indications of the quantity of urea or nitrogen in the urine are of course the more important the more of it is derived from tissue juice and not from daily food; for this proportion assigns the degree in which we get one of the most common results of fever, namely emaciation.

Respiration apparatus.

Liebig's, Davy's, and other analyses for urea.

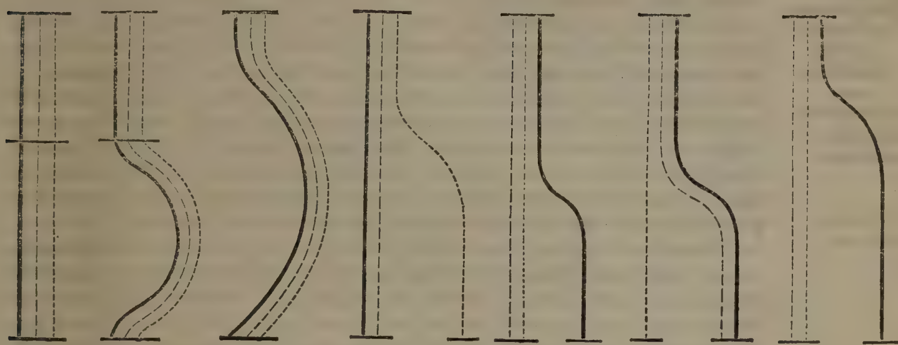
Chlorine does not liberate nitrogen of uromelanine.

Urine in acute fevers not qualitatively changed.

Generally speaking, the febrile process as exhibited in the urine is a quantitative change without final qualitative alteration. At least, so far as present information reaches, the ingredients of febrile urine do not differ qualitatively from those of healthy urine, but are present, some in increased, others like chlorides, in diminished quantities. The qualitative change which takes place in the febrile body occurs intermediately between albumen and urea; and to the rule that all anomalous products of albumen become again urea, only one disease, malignant jaundice, is at present known to form a complete exception; and even here the exception is only complete in the most extreme cases. The products of diseased action are destroyed in the blood like the pabulum of health.

It is interesting to compare with our ordinary acute fevers a number of other diseases which vary the bearing of the constituents of food and blood. Such a comparison, according to my conception of the main features, is represented in the following diagrams; where the continuous lines indicate the course of the albuminous substances, the interrupted

lines that of the fatty, and the dotted lines that of the saccharine elements of assimilated food.



Explanation of diagrams.

Diagram 1 is that of health. The three factors run through the biliary function, indicated by a horizontal line at a place about $\frac{2}{5}$ths from the top of the diagram. Diagram 2 is that of typhus fever. The three factors run through the biliary function, but deviate greatly from the normal afterwards; their products, however, return to normal qualities, *i.e.*, urea, urochrome, carbonic acid, and water, &c. The third diagram illustrates what is believed to be the course of more virulent fevers, such as yellow fever. All factors deviate immediately, the biliary function is not performed, and death occurs at the height of deviation, or the functions return to normal channels. Diagram 4 illustrates the course of diabetes. The amylon and sugar line alone deviates, and that to the end, while both albuminous and fatty matters follow the course of health. In diagram 5, that of cystine disease, the albuminous matters alone deviate, while fats and sugars retain their ordinary course. In diagram 6, that of chylous urine, sugar and starch follow the lines of health, while fats and albumen are at least in part diverted. The 7th diagram exhibits the course of malignant jaundice, in which albumen only is diverted, sugar and fat following the line of health. The disease, therefore, in these great features resembles cystine disease, but differs by the deviation of the albumen taking place before the biliary lysis has been effected upon it, while in cystine disease there is no interruption, but only a partial qualitative change of the biliary lysis, cystine being produced instead of or as well as taurine. In malignant jaundice all biliary lysis ceases at a given period, and no taurine is formed. What has here become of the sulphuretted part of albumen, which should have formed taurine (and which in the other diathesis forms cystine) is not known.

Under all circumstances the greater part of the products of diseased action is destroyed in the blood like the pabulum of health, and turned into ammonia, carbonic acid, and water, or their equivalents. Only in extreme conditions, such as diabetes, or malignant jaundice, the process of conversion indicated by one line or the other is entirely perverted, and the products of the processes indicated by that line are entirely abnormal. Thus in slight degrees or incipient stages of malignant jaundice there is as yet neither tyroine nor leucine, but the ordinary urinary products. In higher degrees tyroine and leucine appear by the side of urea, and in the ultimate fatal stages leucine and tyroine, with other abnormal products, assume the place of urea, which disappears entirely from the secretion.

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Relation of urea to temperature.

In febrile diseases such as are indicated by diagrams 2 and 3, there is a certain relation of urea to temperature observed. But the explanation of this relation meets with difficulties, as several sources of error are found during its consideration. Thus it is impossible to say what was the amount of either food or tissue consumed, and consequently what kind of waste, blood or tissue waste, the urea formed represents. Next, it is impossible to tell the nature of the decomposition preceding the formation of urea, and consequently to calculate the number of units of heat evolved. And even if these were ascertained it would be practically impossible to determine the heat absorbed by the evaporation from skin and lungs, on the one, and that which has to be got rid of by radiation on the other, hand. The error arising from the excretion of a little urea by the skin is so small that it can be neglected.

Generally speaking, it may be affirmed (*a*) that in all diseases with raised temperature urea is increased ; (*b.*) that the process which produces urea produces the fever ; and (*c.*) that the quantitative aberration is preceded by a qualitative one, as shown in the diagrams. But these three conclusions can by no means be reversed, nor are they absolute, though general, because (*d.*) urea may be increased (to double the normal standard) while temperature is lowered. This is the case in diabetes. Diminished heat and diminished excretion of carbonic acid go here hand in hand. (*e.*) Urea may be diminished in acute fever, if other products are discharged instead, the decomposition-heats of which are the cause of the increased temperature observed. (Leucine, tyroine, changed hematine.) (*f.*) These decompositions precede the urea formed by the abnormal process, and their heats are therefore superadded to the heats, which possibly may be, but are not necessarily produced by the ultimate urea formation.

In diabetes urea increases, T. is lower, carbonic acid lessened.

Chronic diseases.

There are chronic diseases which in such respects as are here under consideration show features similar to acute. It is as if certain materials slowly accumulated in certain parts of the body, and presently split up into secondary products of diseased decomposition ; this splitting up evolving heat—the same as that which was absorbed or became latent during the synthesis in which the compound was made, in the plant or animal ; and the secondary products getting oxydised with further evolution of heat, till no diseased products ultimately remain. Such processes seem to be illustrated in the several stages of gout.

Nature of the specific changes.

Of the nature of the specific changes but little is known, and much remains to be ascertained. This is indeed the most difficult task of chemico-pathological inquiry. Some changes are primary, and concern matters which are yet in the intestinal canal, or already in the blood. Others are secondary or results of fever. Many brain-diseases attended by delirium, and also tetanus, are accompanied with decomposition of the sheath of the nerve-fibre, which, as shown by the reaction with perosmic acid, consists of cerebric acid ; and no doubt this decomposition may be produced either by external heat radiated upon the part (as in sun-stroke) or by fever-heat operating through the blood. In acute softening of the brain this decomposition advances so far that glycero-phosphoric acid, a constant product of the decomposition of cerebric acid, is met with in the fluid which surrounds the softened part.

Glycero-phosphoric acid in softened brain matter.

Cases of diminished temperature.

It may be useful to draw attention to the causes and effects of diminished temperature, in order by the contrast to aid in the explanation of those of increased heat. The most direct and immediate cause of sinking of the animal heat is failure of the heart's action, as in a fainting fit. This, sudden and severe, may be caused by terror, or in weakened constitutions even by slight impressions on the mind. A slower but still direct cause of the same effect is external cold. It acts physically by pro-

ducing spasm. During immersion in very cold water (such as that which issues from an alpine glacier with a temperature of 8° C.) the pulse disappears, the limbs shrink, muscular spasms appear in various parts of the body, and the heart gives indications of a tendency to arrest its action. When elements for the production of heat are abstracted from the body (as in starvation, bleeding, and diarrhœa) the same result occurs. And it also forms part of the state of collapse which many poisons (common and morbid) produce. Partial paralysis acts by loss of motion only, but complete paralysis, such as paraplegia, *e.g.*, by severing of the spinal marrow, causes at first a great rise in the temperature. Sections of one side of the spinal marrow produce paralysis of motion with diminished heat on the one, and increased heat and hyperæsthesia on the other side.

Chemical definition of "reaction."

Chemical definition of "crisis."

During the impairment of chemical action in diminished temperature, matters collect which afterwards when they become oxydised (with or without accidental assistance from exterior circumstances) cause an increase of temperature, or so-called reaction. But abnormal matters may also collect by being produced quicker than they can be oxydised, and when they are got rid of by the economy it is also by the process of reaction. Reaction (the manifestation of the chemical destruction of collected abnormal matters) begins with a period termed crisis; and crisis I understand to be the point at which more morbid material is beginning to be oxydised than is produced in equal times.

Critical days doubtful.

I have not been able to convince myself of the existence of critical days, as defined by Traube, namely, the uneven days from the beginning of the disease. Though there might be clinical appearances, the chemical phenomena did not keep parallel to them. The circumstance that in intermittent fever reaction and crisis are indefinitely repeated in definite intervals, points to a limitation of the length of time during which abnormal matters may collect. In remittent fever the intervals are in closer approximation and observe no regular periodicity. In typhus and yellow fever, crisis and reaction are compressed within a very short span of time, and may be possibly imperceptible unless measurements and analyses are made at such short intervals as two hours.

Crisis in intermittent fever.

Crisis in typhus and yellow fever.

Crisis in chronic diseases.

In chronic diseases, on the other hand, crisis and reaction occur at very long intervals. Thus in chronic intermittens, I have observed them every 28 days in the male subject. Gout, again, may show them at intervals of weeks, months, or years. However intervals may vary, the process shows the same course and derivation.

Collateral features of the chemistry of fever.

Abnormal gases.

Carbon leaves the body in breath and urine. In the breath it occurs as carbonic acid and as carburetted hydrogen. The latter in health appears in small quantity, but may perhaps be increased in diseases. The symptomatology of the tongue may be enriched by observations on this point. For abnormal gases during expiration may exercise an influence upon the tongue as well as morbid kinds of saliva and buccal secretions. The origin of the carburetted hydrogen gas is mostly in the intestinal canal. As marsh-gas, $\text{Ꞓ}H_4$, it is a regular constituent of flatus, and of those great and painful collections of gas which produce the tympanites of abdominal typhus. Possibly carbonic acid gas may be secreted from the blood into the intestine when the lungs fail in action. Thus in hydrothorax I have repeatedly observed tympanites and continued eructation of gas. These considerations derive great support from the conception of respiration as being primarily an act of secretion, before it becomes one of absorption as well. But the fact has to be borne in mind, that most of the gas which occurs in the intestinal canal is the product of the decomposition of its contents.

Marsh-gas in tympanites of typhus.

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A measure of disintegration of blood-corpuscles wanted.

The significance of the various nitrogenous bodies in the form of which nitrogen leaves the body during fever, and their relation to each other, can only be found by continued quantitative researches. What we know of urea almost suffices for a theory in which all factors are in harmony. But we must have a measure of the disintegration of the blood, and that we can only find in uromelanine, or better still in a method of determining urochrome with the same despatch as urea. With such a measure we could ascertain the quantitative effects of fever far better than with the thermometer or urea analysis alone. The thermometer gives us a measure of the aggregate chemical changes; the urea a measure of the disintegration of albumen; but urochrome would show us the amount of disintegration of the corpuscular respiring and oxydising part of the blood. Much of the efforts of pathologists must therefore be directed upon obtaining this aid; and consequently my researches of the last two years have lain very particularly in this direction.

B.—*Waxy Degeneration, particularly of the Liver.*

Bacony liver, &c., discovered by Rokitansky.

Waxy degeneration affecting most organs of the body was first described by Rokitansky. He termed it bacony degeneration (Speck-leber) on account of the peculiar consistence which organs, *e.g.*, the liver, assume under its influence. He observed peculiar corpuscles from the size of granules to that of larger animal cells, some of the larger ones of which showed concentric rings. On account of their peculiar consistence, and their tendency to break up under slight pressure like drops of cold jelly, he termed them *colloid* corpuscles. He thus applied to a microscopic formation, the result of the morbid metamorphosis of a natural tissue, an adjective which Laennec had applied to a peculiar kind of tumor, a new growth. Some of the peculiar corpuscles exhibiting a concentrically stratified appearance, Rokitansky following Purkinje, termed (first variety) amylaceous bodies, others (the second variety) he termed *stratified colloid* corpuscles. (Pathol. Anatom. 1, 116.) Virchow examining these corpuscles by means of iodine, observed that they assumed colorations varying from pale blue to blue grey, violet, and brownish, but never purely violet or blue; on subsequent addition of sulphuric acid they assumed a blue, violet, or violet brown colour. This induced him to term the bodies *amyloid* corpuscles, and to attribute to them the properties of cellulose. (Virchow's Archiv. 6, 135; 6, 268; 6, 416; 8, 140; 8, 364.) Busk assented to this because he saw that the corpuscles became blue by the influence of chloride of zinc-iodine (Quarterly Journal of Microscopic Science, 1854, January). It was, however, often observed that organs which had the general characters of this degeneration with iodine and sulphuric acid gave only a mahogany coloration, and no blue whatever. (See Drs. Bristowe and Ord, in Path. Trans. Vol. X.) And an analysis of an extract by potash from a bacony liver, made by Kekulé, had yielded data which showed the extract to possess the composition of an albuminous body. It became, therefore, necessary to establish a distinction between the bacony, or as it is now termed waxy, and the amyloid degeneration, and to examine the chemical differences between the two processes.

Difference between colloid degeneration and colloid tumors.

Amyloid corpuscles.

Distinction between waxy and amyloid degeneration.

An exquisite specimen of a waxy liver from a patient who had been under the care of Mr. Simon was therefore subjected to the following examination. A part of the liver was ground to a pulp, extracted with cold water and filtered. The solution with a little acetic acid, or by itself on boiling, as also with nitric acid, and subnitrite of mercury

(Millon's reagent), gave the reaction of albumen. Evaporated, the residue extracted with alcohol, after evaporation of the alcohol a solution was obtained which gave no reaction with Trommer's test. Consequently sugar was not present in the extract.

Cold water extract contains albumen, no sugar.

Another part of the liver was repeatedly extracted with boiling water, and the extracts were united and evaporated to a syrupy consistence. Pettenkofer's test gave no reaction, so that bile-acids were absent. No sugar could be detected either in the residue or its evaporated alcoholic extract.

Hot water extract contains no bile-acids, no sugar.

Alcohol extract.

Contains cholesterine, no bile-acids, little cholophæine.

Fatty acids.

Benzoic or succinic acid.

The pulp, which had been extracted with hot water, was boiled with alcohol, and the decoction filtered hot. The filtrate was evaporated to dryness and redissolved in a small quantity of boiling absolute alcohol. On cooling of this solution a considerable quantity of cholesterine was deposited. The crystals were mixed with drops of fat. The filtrate from this deposit was again tested for biliary acids, but none were found. With nitric acid a feeble reaction of green, blue, and violet was obtained. As the alcohol reacted rather violently with the acid, the solution was diluted with twice its bulk of water, whereby a milky precipitate ensued. This was completely soluble in much acetic acid (fatty acids). When to the turbid solution chloride of iron was added a dark yellow precipitate ensued, which may have been benzoate or succinate of iron.

A part of the liver was comminuted and heated with hydrochloric acid. The dark purple solution was filtered, heated on the water bath, and treated with small quantities of chlorate of potash, until the fluid ceased to froth and was clear yellow. On the top there was some fat, at the bottom of the fluid there was a small quantity of a yellow flaky precipitate. This was easily soluble in alcohol. It follows from this that gelatine is absent, and that the main bulk of the matter behaves like syntonine.

No gelatine, but syntonine.

No part of the liver, fresh or extracted with alcohol, gave with iodine, or iodine and sulphuric acid, any reaction indicating the presence of amyloid or cellulose matters. The particles only assumed a mahogany brown colour.

No amyloid reaction.

Results.—The waxy liver contained of abnormal substances syntonine, cholesterine, and benzoic or succinic acid. Biliary acids and sugar were (abnormally) absent; a trace of cholophæine was present. Only very little fat was met with. Consequently the degeneration consists mainly in the displacement of gelatiniform tissue, and the disappearance of sugar and biliary acids, with the abnormal deposition of syntonine (or a matter behaving like syntonine) and cholesterine.

Results.

C.—*Determination of the Quantity of Sugar circulating in the Blood in a case of Diabetes.*

Question.

It has been affirmed that the proximate cause of the symptoms of diabetes is melitæmia. And undoubtedly sugar has been found abundantly in blood examined in the usual way after withdrawal from veins. But it was not quite certain that all this sugar, or any of it, existed in the blood while circulating, and that there had not been a post-mortem or rather a post-venesectionem change of some glycogenous material into sugar. Moved by these considerations Mr. Simon suggested the following experiment, which was accordingly carried out at St. Thomas's Hospital. 69 grammes of blood were withdrawn by venesection from the arm of a female diabetic patient. Of these 29 grammes were received directly into 75 grammes of absolute alcohol yielding 104 parts of mix-

Experiment.

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ture. This after two filtrations was by nitric acid and boiling found free from albumen. It was now examined with a saccharometer, to be more fully described in the following. In this apparatus a diabetic sugar solution of 4·75 °/$_\circ$ compensated (a) 0·72 ; (b) 0·71 ; (c) 0·71 = mean 0·71 inches of scale adjusted to left turning oil of turpentine.

Result.

The blood extract compensated 0·01 inch, equal to $\frac{4\cdot76}{71}$ = 0·067 °/$_\circ$ of sugar in mixture. Multiplying this by $\frac{104}{29}$ = 3·58 we get 0·2398 °/$_\circ$ of sugar in blood. Taking the whole of the patient's blood at 4,500 cubic centimetres, it would after that rate contain 10·8 grammes of sugar. The second portion of blood, measuring 40 cubic centimetres, which had been drawn with the above, but not into alcohol, was after 24 hrs. standing treated in exactly the same manner as blood 1. Blood 40 gms., alcohol 103 gms., mixture 143 gms. In the saccharometer the filtered mixture compensated exactly 0·01 inch of left-turning turpentine. Consequently this second blood contained neither more nor less sugar than the first. The alcoholic extracts, after evaporation of the alcohol and resolution of the residue in water, gave the test for sugar with alkaline copper solution.

Jellett's polarimeter.

Jellett's Polariscope.—The foregoing observations were made with a polarimeter which was invented a few years ago by Mr. J. H. Jellett, Professor of Natural Philosophy in the University of Dublin. As this instrument is by far the most accurate polarimeter extant, but is nevertheless little known and less used, I think it almost a duty to give a short description of it in this place, accompanied with such illustrations as will make its construction readily understood. The description will closely follow the inventor's account, as given in vol. vii. of the Proceedings of the Royal Irish Academy. The instrument represented in the woodcut, and which was employed in the foregoing analyses, is by Mr. Spencer, philosophical instrument maker, of Dublin.

Drawbacks of ordinary Nicol's prism.

In determining the plane of polarization of a ray by means of the ordinary Nicol's prism, the observer is required to arrest the rotation of the prism at the point at which the intensity of the transmitted light is at a minimum. But it is difficult to do this with very great accuracy, inasmuch as the observer is obliged to compare a shade of colour not with any other shade which is before his eyes at the same instant, but with his recollection of a shade observed at the previous instant. To insure any tolerable degree of accuracy the observation must be made very rapidly, so that the eye may receive the new impression while the former one is still quite fresh in the memory. The difficulty of doing this with accuracy in any case is obvious, but it is most felt in experimenting on light reflected or transmitted by fluids. For here it is impossible to touch the instrument without producing a tremulous motion in the fluid, and therefore in the image reflected or transmitted; and this motion while it lasts renders accurate observation very difficult. But if the rotation of the analysing prism be stopped for a sufficient length of time to allow this motion to cease, the recollection of the previously existing tint will no longer be so fresh as to allow the comparison to be made with any very great exactness. The difficulty will be increased, as is easily seen, when there is any amount of elliptic polarization in the light which is to be examined.

Remedy by simultaneous tints.

The remedy for this difficulty Mr. Jellett sought in the construction of an analyser in which the tints compared should be *simultaneous*, not consecutive. The double quartz plate of Arago was an attempt to realize this conception. It has, however, no similarity in principle to, and does not approach in accuracy, the following instrument devised for this purpose by Professor Jellett.

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Prism cut and divided.

A rhombic prism of Iceland spar, whose longitudinal edges should have a length of about two inches, or a little more, is cut by two planes perpendicular to those edges, so as to form a right prism, as in the engraving, Fig. 1.

Fig. 1.

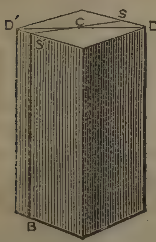
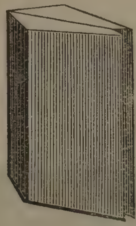


Fig. 2.



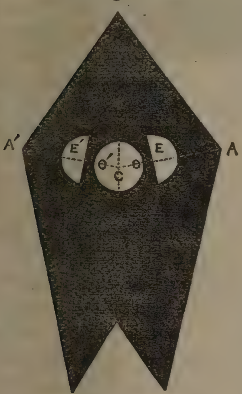
One half of prism turned 180° round centre of plane of section.

This prism is next divided by a plane S S′ B, parallel to the edges and making a small angle with the longer diagonal of the terminal face D′ D; one of the two parts into which the prism is thus divided is then reversed, so as to place the base uppermost; the two parts are cemented together, as in Fig. 2, with the surfaces of section in contact, and the ends of the prism thus formed are then ground and polished.

Peculiar refraction in new prism.

Now it is evident from the construction of the prism, that if two rays of light parallel to the axis be made to traverse the two parts of the prism respectively, the lines of separation of the ordinary and extraordinary images in these two parts will be C A, C A′, Fig. 3; and as the angle between the plane of section and the longer diagonal is small, the angle A C A′ is nearly 180°. Hence the extraordinary refractions in the two parts are in nearly opposite directions; and if the end at which the light is admitted be so chosen that these refractions shall be *from* the plane of section, the separation of the images will be nearly doubled.

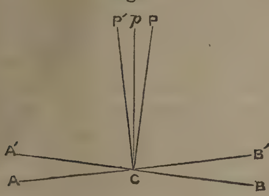
Fig. 3.



Now suppose a circular beam of plane-polarized light to traverse the prism in a direction parallel to the sides, and so as to be equally divided by the plane of section, the emergent beam will consist of three separate parts, viz., (1) a circular beam, O C O′, Fig. 3, formed by the union of the two ordinary beams; (2) two semicircular extraordinary beams, E E′. If, then, the size of the incident beam be suitably determined, these latter may be completely separated from the ordinary beam, so as to admit of their being stopped by a diaphragm which allows the ordinary beam to pass; the instrument will then transmit a single beam of plane polarized light.

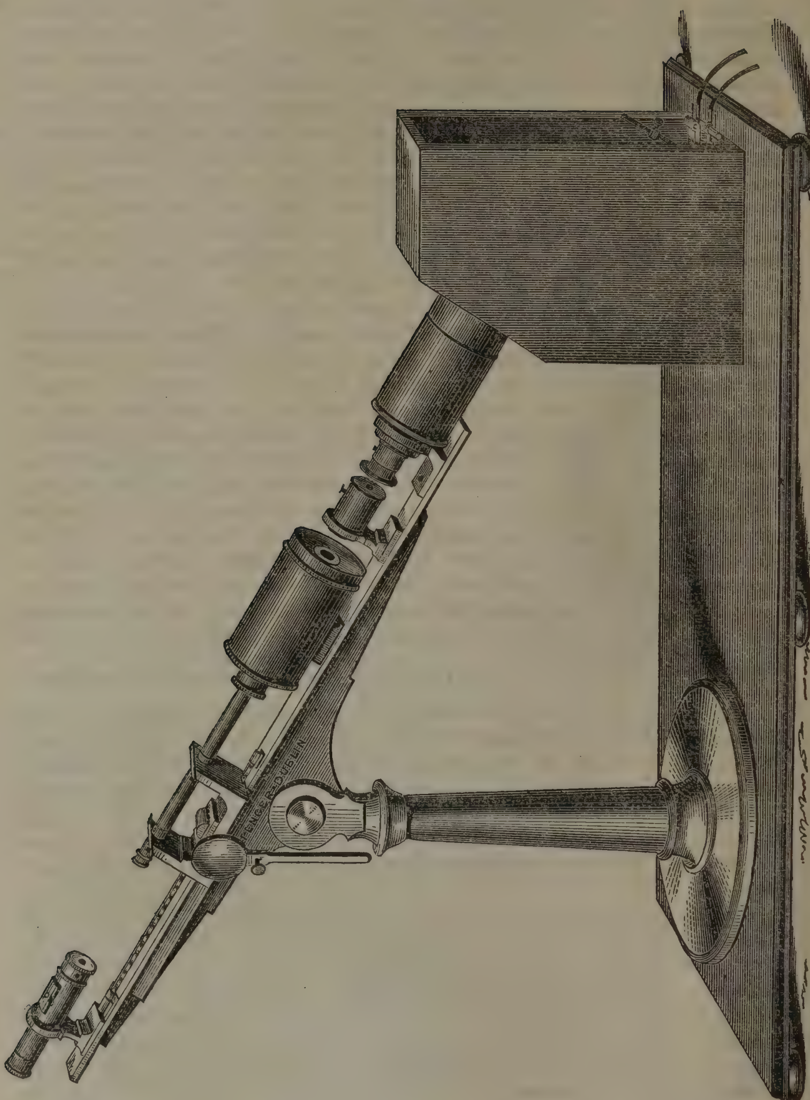
Now it is easy to see that the planes of polarization of the two parts into which the beam is divided by the plane of section are inclined to each other at an angle somewhat less than double the angle D C S, Fig. 1. Suppose, then, that the plane of the paper being perpendicular to the beam, the traces of these planes of polarization are represented by A B, A′ B′, Fig. 4, and let C P and C P′ be perpendicular to these lines respectively. Let C p be the plane of polarization of the ray to be examined.

Fig. 4.



Then so long as there is any difference between the angles P C p, P′C p, the intensities of the two parts of the beam will be different, and conversely, if these intensities be equal, it is evident that the required plane of polarization will bisect the angle P C P′. The prism must therefore be turned on its axis until the equality of tints be established, and when this is done, the position C p of the plane of polarization is known. It is not, how-

Fig. 5.



ever, necessary to determine the position of the planes P C, P′ C. The observer commences by transmitting a beam whose plane of polarization is known, and turning the analysing prism until the tints become equal. The beam whose plane is required is then introduced, and when the equality of tints has been re-established, the angle through which the prism has revolved, read off on a graduated circle, gives the inclination of the required plane to the known plane. This mode of determining the zero, a process which for perfect accuracy ought to be repeated with each new set of observations, possesses the advantage of eliminating the personal equation of the observer. In examining a beam of any considerable magnitude, there will be found in different persons a tendency to think one part of the image darker than another, even when there is no real difference. With different observers, and even in the same person at different times, the part of the image thus preferred may be different, and if the zero were determined once for all this might occasion sensible error. But as in the method here given such a preference will equally affect the position of the zero, it can have no influence on the final result.

In the first prism which Prof. Jellett caused to be constructed the angle between the planes C P, C P′ was about 7°. With this prism the range of error in the determination of a plane of polarization was 7′, the light employed being the diffused light of the sky. Although this was a very much smaller range than he had ever been able to obtain with a Nicol's prism, it seemed that a greater amount of accuracy might be obtained, and as the brightness of the image appeared to be too great, a prism was constructed in which this angle was but half of its former value. With this prism and with the same kind of light the position of a plane of polarization could be determined to 1′. With direct solar light and a prism in which the planes are still closer, a greater degree of accuracy may certainly be obtained; in fact, it can be shown that by diminishing this angle and increasing the brightness of the light, so as to preserve unchanged the intensity of the image, the sensibility of the prism will vary as $\cot \frac{\theta}{2}$, θ being the angle in question.

The prism here described is fixed in the eyepiece or analyser of the apparatus, the general aspect of which is given in the accompanying Fig. 5. But while the rotation of the prism necessary for determining the zero point is effected by little screws fixed to the tube a little below the ring by which the eyepiece is fixed to the beam on which the axis of the instrument is carried, the mechanical rotation of the analyser for the finding of any particular plane is altogether dispensed with, and this function is transferred to a fluid which has the power of turning the plane of polarization in a direction opposite to that which it is intended to determine in the casual observation. This fluid may be any polarizing solution of stationary power. In the present instrument, however, right or left turning spirit of turpentine is used. Of this polarizing turpentine the rotating index per inch, tenth, or hundredth of an inch is ascertained as expressed in per cents. of sugar contained in solution in the analysing tube. The analysing tube dips into and moves up and down in the turpentine itself. This arrangement will be more intelligible by the aid of the subjoined Fig. 6.

Fixing of the zero point.

The order of events in an actual analysis now is as follows: (1.) *Finding of the zero point.* A beam of parallel light produced in the closed box at the end of the apparatus, by means of the oxyhydrogen-calcium light and a compound condenser, is thrown in the direction of the optical axis of the apparatus. It passes first through the polarizing prism. The polarized beam then enters the bottom of the turpentine bottle. The long tube containing water is pushed down to the bottom

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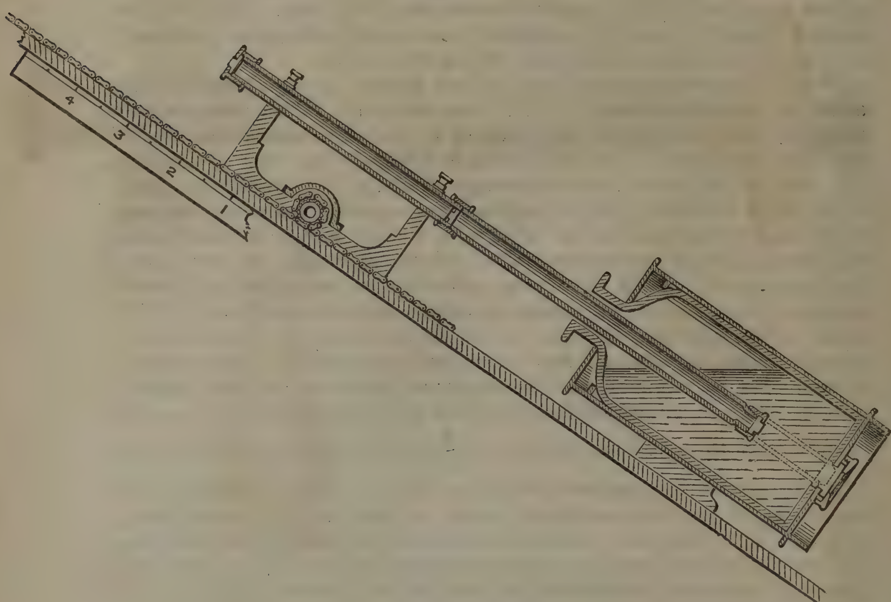
Finding the index of the turpentine.

of the turpentine bottle, until its glass plate rests upon the plain surface of the inside of the turpentine bottle. The arrow of the indicator is placed upon the zero point of the scale attached to the side (of which a portion is represented in Fig. 6), and the analysing eyepiece is now turned until the tints of the half-circles of its picture are equal. (2.) *Finding of the index of the turpentine as expressed in per cents of sugar.* The tube containing water, and intended to contain the fluid to be analysed, is now filled with a solution of dextrose sugar containing 10 per cent. of sugar, which turns the plane of polarization to the right. If the tube be replaced as before, the tints of the picture in the analyser will now be unequal. The tube carrying the sugar solution is now raised upwards by means of the milled-headed wheel, until the tints of the two halves of the picture in the analyser are again equal. By that means a column of oil of turpentine (turning to the left) will have been inter-

Fig. 6.



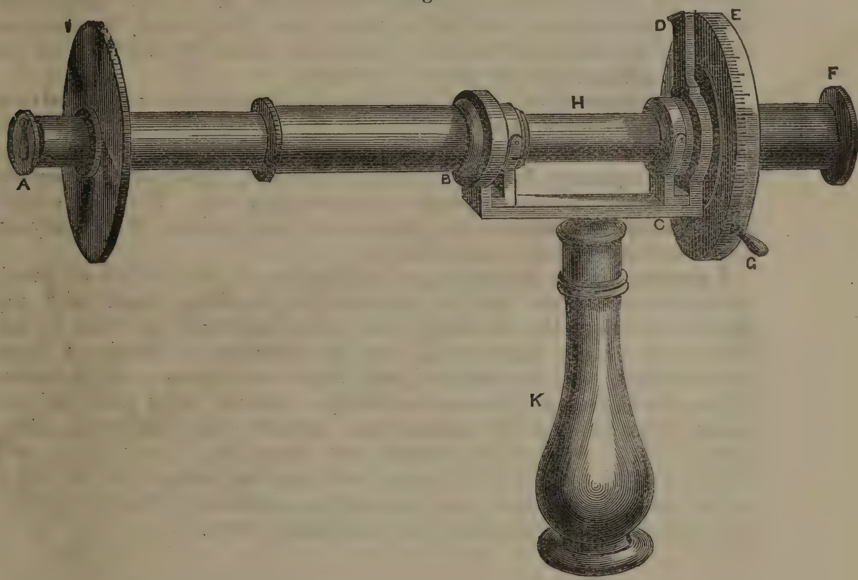
posed between the sugar solution and the polarizer (as shown in Fig. 5), which turns the plane of polarization as much to the left, as the tube full of ten per-centic sugar solution turns the plane of polarization to the right. Both polarizations will have completely neutralised each other. Supposing the arrow stand upon 1 of the scale, then a column of one inch of left-turning turpentine has been required to neutralise the polarization of a solution of 10 per cent. of sugar in the tube. If now a solution containing either more or less sugar be placed into the tube, a longer or shorter column of turpentine will be required to neutralise its effects. And as the effect of a column of one inch (in the above example) is known to indicate 10 per cent., the effect of any length, or its sugar-indication, can be found by the equation $1 : 10 = t : x$, in which t is the length of the turpentine column measured on the scale, and x the per-centage of sugar contained in the problematical fluid in the tube. I have not entered into minor details of the construction of this apparatus, such as the chain in connexion with the milled wheel by which the closed tube is moved up and down in the turpentine bottle, or the long lever attached to the milled wheel for

delicate adjustment. These must be studied upon the apparatus itself, and like the entire apparatus itself will be found to leave nothing to be desired in respect of mechanism. No other polarimeter approaches this instrument in accuracy for such saccharometrical purposes, as with care it indicates 0·01 °/$_{o}$ of sugar. But its disadvantages are that it requires powerful artificial light, that it is cumbrous and complicated and must be skilfully managed, and that its price is necessarily very high. It cannot yet be made to indicate the polarization of any particular ray of light, say the yellow or the green, and it will probably be better not to attempt to complicate it with any arrangement for that purpose.

Wild's polarimeter.

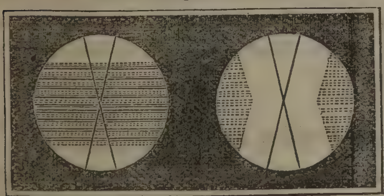
Wild's Polarimeter.—This instrument, represented in Fig. 7, is very handy for general purposes in which only approximative results are required. It is held by the hand at K, and A is directed towards the

Fig. 7.



light of a candle, oil-lamp, or gaslight, while the eye is applied at F. At A the tube contains a Nicol's prism. At B a Savart's polariscope is fixed consisting of thick pieces of quartz with intermediate lenses and a wire cross of the shape represented in Fig. 8. The eyepiece F carries a second Nicol's prism, which turns with the disk E, carrying the division of the circle on its circumference. For the greater convenience of manipulation a lever G is fixed in the disk. The zero point and nonius are immoveable at D, and B C is the arrangement by which the handle is fixed to the instrument. I is a black disk, intended to further screen the eye from the direct light, and H is the tube in which the fluid to be examined is placed. When the eye receives the transmitted light of the apparatus, while the divided circle is in any position except those where 0°, 90°, 180°, 270° are exactly incident with the zero mark of D, then a

Fig. 8.



picture sketched in the left-hand circle of Fig. 8 is seen, consisting of striæ of interference running horizontally through the entire field of vision. But when 0°, 90°, 180°, or 270° are placed exactly upon the zero point at D, the transverse striæ are not visible in the middle of the field, where now the wire-cross alone is visible, as represented in the right-hand circle of Fig. 8. If now the tube X is filled with any fluid possessing the property of circular polarization, and is placed into the position indicated in the engraving, and if at the same time the zero point at D is made coincident with 0° of the rotating disk, the striæ of interference will be visible, and will only disappear after the disk E has been turned a little to the right or to the left. In case the fluid contained in the tube H causes a rotation above 5°, the striæ of interference only become weaker, but do not disappear entirely from the middle of the field of vision in any position. If the rotation was less than 5°, and the point has been attained at which, as in Fig. 8, II., the interference striæ in the middle of the field of vision have disappeared, the observer may read the amount of rotation towards the left or right side which the fluid has effected by reference to the scale.

In case the rotation of the fluid amounts to more than 5°, it is advantageous to employ monochromatic light for determining the amount of polarization. This may be done simply by fixing a plate of red glass before the aperture A, or using as the source of light a spirit flame the wick of which has been drenched with common salt. With such light the striæ by interference disappear at a certain position of the analyser, may the rotation be ever so great.

I am engaged in elaborating a combination of the method of Broch for determining the specific rotation of polarizing fluids with my spectro meter. Dr. A. Dupré has also informed me that he has elaborated a new polariscope, but the mechanical details of these attempts are not yet completed, and their description must therefore be reserved for a future opportunity. Seeing how many of the fluids or products of the animal body possess polarizing action, albumen, gelatine, the various sugars and dextrines, biliary acids, and others, we are not likely to form an exaggerated estimate of the value of an accurate yet ready and expeditious method of polariscopy and polarimetry for physiological and pathological research.

D, E, F.—*Further Researches on Urochrome.*

Synopsis of the Products of Chemolysis of Urochrome.

A. Fixed Products of Decomposition by Sulphuric Acid.

Insoluble in ether, all soluble in ammonia.	Uromelanine	Insoluble in alcohol.
	Uropittine	Soluble, sparingly, in alcohol.
	Urorubine	Soluble, easily, in alcohol.
	Metauropittine	Soluble in alcohol.
Soluble in ether and alcohol.	Omicholine	Insoluble in ammonia.
	Omicholic acid	Soluble in ammonia.

B. Volatile Products of Decomposition by Sulphuric Acid.

Soluble in ether		Essential oil.
As sodium salts in soluble in ether.	Acetic acid.	
	Uncertain volatile acids.	

D.—*Omicholine; and* E.—*Omicholic Acid.*

Synopsis of the Preparations of Omicholine and Omicholic Acid obtained in this research.

A. I. A. II.	used up in first analyses and tests.	
A. III.	Putrid urine.	
B. I. B. II. B. III.	United as B.	*a.* Portion insoluble in NH_3, or omicholine. Three elementary analyses. *b.* Portion soluble in NH_3, or omicholic acid. Two elementary analyses.
C. I. D. I.	Before boiling therefore united as C.	*a.* Portion insoluble, or omicholine. Four elementary analyses. *b.* Portion insoluble, or omicholic acid. Two elementary analyses.
C. II. D. II. D. III. D. IV.	United as D. (with C.) after boiling.	*a.* Portion insoluble in NH_3, or omicholine. Three elementary analyses. *b.* Portion soluble in NH_3, or omicholic acid. Four elementary analyses.

Mode of obtaining omicholine, &c.

Mode of obtaining.—The mixture of substances which alcohol extracts from the chemolytic products of urochrome (which are insoluble in the acid mother liquor and in water) is evaporated to a small bulk, and then poured into water. The precipitate is collected on a filter and washed until all traces of impurities have disappeared from the filtrates. The matter is now allowed to dry spontaneously, or in vacuo over sulphuric acid (not by heat, as the matter fuses and penetrates into or through the paper), and then in a flask extracted with ether. This operation is very difficult, as the matter cannot be powdered, and in the ether immediately settles in the form of smeary hard lumps. However, after weeks of continued extraction all resinous matter has passed into the ether, and a pulverulent matter, uropittine (perhaps urorubine), and some uromelanine, remain undissolved. The ethereal solution is of a bright port-wine red colour, and peculiar, independently of the ether, penetrating odour. When the ether is allowed to evaporate spontaneously, or distilled off, a red syrup remains, which may become hard, but never shows any signs of crystallisation. It was this body which I had described as omicholic acid in the Hastings Prize Essay. The following will show that it is a mixture of two closely related bodies, which can, however, be separated to some extent, though imperfectly.

Separation of omicholine from omicholic acid.

Mode of separating Omicholine from Omicholic Acid.—The resin is treated with concentrated liquor ammoniæ and warmed. A portion dissolves, while another portion settles as a thick brown oily liquid. The alkaline solution is decanted and allowed to stand, when it will deposit more of the oily matter. (This portion is rejected, as being probably a mixture of omicholine and omicholic acid, which it is impossible entirely to separate.) When the alkaline solution in a covered vessel does not deposit any more oily matter, it is considered free from omicholine, and to contain only omicholic acid dissolved with ammonia, and some uropittine. The deposit is omicholine.

Purification of Omicholic Acid.—To the watery ammonia solution some $BaCl_2$ is given, which precipitates most of the uropittine and any trace of uromelanine which may be present. (The Ba salt in one case gave 20 % Ba.) The filtrate is acidified with hydrochloric acid, which precipitates all omicholic acid as resin. It is washed with cold water.

Appendix.

No. 6.
On Chemical Identification of Disease, by Dr. Thudichum.

If no uropittine be discovered by testing, sulphuric acid is added to the ammonia solution. In this case a precipitate ensues, but much omicholic acid remains in solution. On evaporation of the acid liquid it is deposited in drops. All omicholic acid is easily taken up by ether from the acid watery liquid or mixture.

Purification of Omicholine.—The deposited omicholine is mostly free from uropittine and uromelanine, which easily dissolve in the watery ammonia; but it must be well washed with water, and a trace of acid, before it is pure.

Ultimate purification by ether.

Ultimate Purification of Omicholine and Omicholic Acid.—Each of these bodies is dissolved in absolute alcohol, and to this solution six volumes of absolute ether are added. Any precipitate is impurity, either uropittine or other matter. When the mixture remains clear the matter dissolved in it, provided it has been treated as above stated, must be considered as pure as in the present state of our knowledge it can be obtained.

Chemical properties of omicholine.

Chemical Properties of Omicholine.—It is semi-fluid to resinous, becoming harder by keeping. It has a red colour and strong peculiar odour. It is little soluble, or insoluble in concentrated caustic ammonia, and does not combine with barium salts. It is soluble in caustic potash, and again precipitated by sulphuric acid. It is a little soluble in cold water on standing, a little more soluble in boiling water, with a yellow colour; the solution becomes turbid on cooling. The cold watery solution becomes turbid on addition of a little sulphuric acid; on heating it clears up again. The watery solution, hot or cold, gives a precipitate with (1) sulphuric acid and iodine dissolved in iodide; (2) with mercury oxyde nitrate, yellow white; (3) with the same and subnitrite or nitrite of suboxyde a red reaction like tyroine. All watery solutions are strongly fluorescent. Silver nitrate gives no immediate precipitate in the hot saturated watery solution, but on standing a precipitate is formed. Its spectral phenomena are most remarkable, and have already been alluded to on p. 271 of the Report for 1868. The ether solution is of a ruby red colour, but fluoresces green in the cone of the sunlight. In the spectroscope it shows an absorption band in green.

$$141^\circ\ 42' - 141^\circ\ 12' = 0^\circ\ 30'\ \text{Int. 5. R. } \alpha.$$

Near to it in green there is a shading.

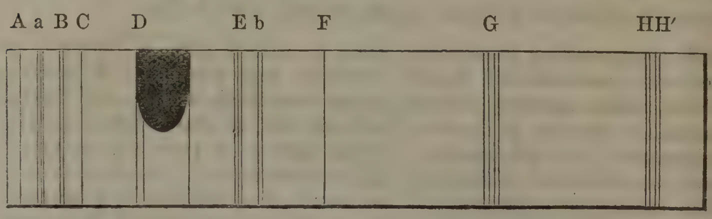


Diagram of Spectrum of Omicholine.

The red and yellow are very brilliant; the rest of the spectrum after green has a violet hue, without any blue.

Physical and Chemical Properties of Omicholic Acid.—This acid is of a red colour, resinous, fusing when heated, and giving out the aromatic strong odour reminding of castoreum. It is little soluble in water, more in ether, best in absolute alcohol. It dissolves in concentrated watery

ammonia, and more easily in caustic potash. The ether solution, which is ruby red, shows an absorption band in green.

141° 36′—141° 18′ = 0° 18′. Int. 5. R. *α*.

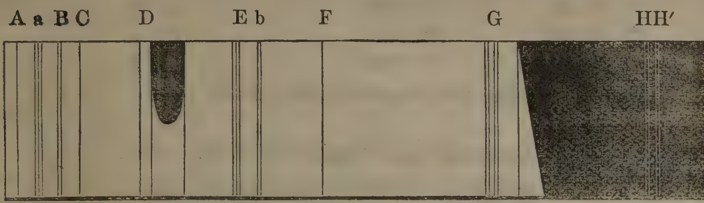


Diagram of Spectrum of Omicholic Acid.

The blue part of the spectrum is coloured violet. Green shaded at 141° 12′. Omicholic acid in chloroform has the same spectrum; but as the solution can be obtained more concentrated than the ether solution, the violet, blue, and nearly the whole of the green part of the spectrum, are cut off entirely immediately to the right of the absorption band. The ammoniacal solution of omicholic acid has no bands in the spectrum. Omicholic acid is red and fluoresces green in the sunlight-cone, or that of the electrical lamp, but its phenomena differ slightly from those of omicholine.

Elementary Composition of Omicholine.

Specimen A.

The specimens A. I. and A. II., described originally in the Hastings Prize Essay, when lately again examined had been dried and kept in vacuo for three years. They were reddish-black, tough, hard, easily fusing in heat, and of the most powerful peculiar odour. Six elementary analyses gave results such as might be expected from a mixture of omicholine and omicholic acid, of which the substance was subsequently found to consist.

Omicholine and Omicholic Acid. Specimen B.

Specimen B.

This specimen was suspected to contain traces of uropittine and urorubine, and upon it were performed most of the experiments which led to the information relating to the separation of omicholine and omicholic acid given in the foregoing. The drops of omicholine, which before treatment with ammonia had been acid, after removal of omicholic acid, and much washing with water, remained alkaline.

From the omicholic acid in ammonia $BaCl_2$ precipitated flakes which were dried at 100; 0·3364 grm. left after burning and heating with ammonium carbonate 0·1069 grm. barium carbonate, equal to 20·28 °/$_\circ$ of Ba (uropittate). From the filtrates omicholic acid was recovered by the addition of hydrochloric acid.

Elementary Composition of Omicholine. B, a.

Elementary composition of omicholine.

1. Dried at 85° C. 0·2621 burned with lead chromate, lastly with oxygen, gave 0·6268 CO_2 and 0·2318 H_2O, equal to 65·22 °/$_\circ$ C and 9·82 °/$_\circ$ H.

2. 0·1306 burned as before gave 0·3071 CO_2 and 0·1207 H_2O, equal to 64·13 °/$_\circ$ C and 10·26 °/$_\circ$ H.

3. 0·1754 burned with soda-lime, &c., left 0·0396 Pt, equal to 3·20 °/$_\circ$ N.

Found mean by analyses.

	Quotient by At. W.	Quotient by N = 1.
C 64·67	5·3891	23·5
H 10·04	10·0400	43·9
N 3·20	0·2285	1·
O 22·09	1·3806	6·04

Leading to formula $C_{24}\ H_{44}\ NO_6$.

Elementary Composition of Omicholic Acid. B, b.

Dried for 48 hours at 85° C. Contained a trace of iron.

1. 0·2042 burned in lead chromate, ultimately in oxygen, gave 0·4766 CO_2 and 0·1496 H_2O, equal to 63·65 °/₀ C and 8·14 °/₀ H.

2. 0·2892 burned in soda-lime gave 0·0952 Pt, equal to 4·67 °/₀ N,

In 100.		Quot. by At. W.	Quot. by N = 1.
C	63·65	5·304	15·92
H	8·14	8·140	24·44
N	4·67	0·333	1·
O	23·54	1·471	4.41

Formula $C_{16}\ H_{24}\ NO_4$.

Synopsis of Preparations from Resins C.

Omicholine and Omicholic Acid.

Omicholine, C, a.
Omicholic acid, C, a.
Omicholine, C, b. } Contained Ba salt 17·17 °/₀.
Omicholic acid, C, b. }
United form Omicholine, C, a. } With which O. and Oc. acid from
and Omicholic acid, C, b. } DI are united.

Uropittine.

Uropittine, C, α, 1 (⌣ from cold alc.),* Ba salt : 20·21 °/₀ Ba; Ag. salt : 21·39 °/₀ Ag. Peculiar Bearing with NH_3.
Uropittine, C, α, 2 (⌣ by ether). 4 elementary analyses.
Uropittine, C, α, 3 (⌣ by ether). Ag salt, boiled : 38·71 °/₀ Ag. Other salt, not boiled, 35·49 °/₀; Ag; Ba salt 7·1 °/₀ Ba.
Uropittine, C, β, 1 (depos. from alc.) Ca salt : 1·78 °/₀ Ca; 12·16 °/₀ N.
Uropittine, C, β, 2 (do. on concentration) Ba salt : 21·77 °/₀ Ba Ag salt, 27·14 °/₀ Ag.
Uropittine, C, β, 3 (⌣ by 5 vols. of ether). Ag. salt : 27 °/₀ Ag.

Uromelanine.

Uromelanine, C.

Treatment of the mixed Resins C.

(*a.*) *Extraction by cold Ether. Isolation of Omicholine and Omicholic Acid.*

The mixture was exhausted with cold ether, which assumed a port-wine red colour, becoming lighter at every operation. The ether was

* The symbol (⌣) indicates "precipitated."

evaporated until a residue of oily consistence remained, which was found to be a mixture of two bodies, omicholine and omicholic acid. They were separated as follows—

Separation of Omicholine, C, a, from Omicholic Acid C, b.

The oily resinous residue was treated warm with a large bulk of concentrated watery solution of ammonia. One part dissolved and remained dissolved on cooling, *omicholic acid*,—another part remained insoluble, *omicholine*. The latter represented a liquid resin of strong smell, and appeared to possess most of the qualities of the substance termed *urerythrine*.

Further testing of Omicholic Acid, C, b.

To the ammoniacal solution barium chloride was added, with the view of producing an omicholate. An insignificant precipitate only was obtained, insufficient for analysis. The filtrate was rather dark coloured, showing that the barium had precipitated but little matter. The main bulk of the omicholic acid seemed to be precipitated by hydrochloric acid in light-brown flakes ; but it was changed in its properties to the extent of being less soluble in ether and alcohol than before.

(*b.*) *Extraction by boiling Ether, and Examination of Products.*

The boiling ether seemed to extract more of the two bodies, which were separated as above. To the ammoniacal solution of omicholic acid, C, b, barium chloride was added, and the precipitate filtered off. It was washed with water until the filtrates were free from barium. The precipitate on the filter was next repeatedly washed with alcohol, when it was found that a quantity of uncombined omicholine had been left on the filter. During the precipitation of a barium compound, therefore, omicholine and omicholic acid had been precipitated from the ammoniacal solution. The salt, which remained insoluble in alcohol, was analysed.

1. 0·2369 grm. yielded 0·0715 $\text{Ƀa}\ \text{S}\!\!\!-\!\!\text{O}_4$, equal to 17·74 °/$_0$ Ƀa. The residue contained a trace of iron, which was corrected in the following analysis:—

2. 0·1953 grm. yielded 0·0569 $\text{Ƀa}\ \text{S}\!\!\!-\!\!\text{O}_4$ equal to 17·13 °/$_0$ Ƀa.

This barium compound therefore was shown to be an admixture of the omicholic acid, and not to contain any of this acid. As was proved more fully, omicholic acid does not combine with barium. It is therefore a sign of the purity of omicholic acid that its ammonia solution does not give a precipitate with barium chloride. Again, Ƀa Cl_2 is a means of purifying the ammoniacal solution of omicholic acid, particularly of that which has been obtained by means of cold ether, from another body.

Omicholine C, a, and omicholine C, b, were united, washed with pure water, and again dissolved in ether. They will in the following be designated as *omicholine C, a.*

The ammoniacal solution to which Ƀa Cl_2 had been added, omicholic acid C, a, and omicholic acid C, b, were united and treated with hydrochloric acid. A flaky precipitate fell down, which was washed, and in the following will be designated as *omicholic acid C, b.*

With these preparations the respective preparations from D. I. were united, because both had been obtained from the extract of urine by the mere addition of sulphuric acid without any boiling.

Elementary Composition of Omicholine C, a.

1. 0·3063 gms. dried at 85, (contained like all preparations of omicholic acid and omicholine in little boats of glass shaped for the purpose,) were burned in lead chromate, and gave 0·7859 CO_2 and 0·2962 H_2O equal to 69·97 % C and 10·74 % H. (The water contained a vestige of copper oxyde dust.)

2. 0·2863 gave 0·7275 CO_2 and 0·2458 H_2O equal to 69·31 % C and 9·54 % H.

3. 0·3193 gave 0·0746 Pt equal to 3·31 % N.

4. 0·2602 gave 0·0746 Pt equal to 4·06 % N.

Mean in 100.	Quotient by At. W.	Quot. by N = 1.
C 69·64	5·8033	22·
H 10·14	10·1400	38·5
N 3·68	0·2628	1·
O 16·54	1·0337	3·9

Leading to formula $C_{22} H_{38} N O_4$.

Elementary Composition of Omicholic Acid C, b.

Was brittle at 85° C., fused at 95°. Dried during 48 hrs. at 85°.

1. 0·1656 gms. burned with lead chromate and oxygen gave 0·3836 CO_2 and 0·1130 H_2O equal to 63·17 % C and 7·58 % H.

2. 0·2450 gms. burned with soda-lime, &c., gave 0·0845 gms. Pt equal to 4·89 % N.

In 100.	Quot. by At. W.	Quot. by N.
C 63·17	5·264	15·08
H 7·58	7·580	21·71
N 4·89	0·349	1·
O 24·36	1·522	4·36

Formula $C_{15} H_{21} N O_4$.

Omicholine and Omicholic Acid D.

The ether extracts of preparation C. II. and D. II., D. III., D. IV., were united and treated together, as they had been obtained after boiling of the extract of urine with sulphuric acid. The residue was purified, and the substances separated as above described.

Elementary Analyses of Omicholine D, a.

1. 0·2770 burned with lead chromate gave 0·6732 CO_2 and 0·2030 H_2O equal to 66·20 % C and 8·14 % H.

2. 0·2043 burned with soda-lime, &c., gave 0·0536 Pt equal to 3·72 % N.

3. 0·1004 grm. gave 0·2240 Pt = 3·39 °/₀ N.

In 100.		Quot. by At. W.	Quot. by N = 1.
C	66·20	5·516	21·80
H	8·14	8·140	32·17
N	3·55	0·253	1·
O	22·11	1·384	5·47

Formula = C_{22} H_{32} N O_5.

Elementary Analyses of Omicholic Acid D, b.

Of all the resins obtained this was the most liquid. Dried at 85° until constant—

1. 0·2534 burned with lead chromate, lastly with oxygen, gave 0·6050 CO_2 and 0·1865 H_2O equal to 65·11 °/₀ C and 8·17 °/₀ H.

2. 0·3062 burned as (1) gave 0·7261 CO_2 and 0·2344 H_2O, equal to 64·67 °/₀ C and 8·50 °/₀ H.

3. 0·2386 burned with soda-lime, &c., yielded 0·0856 Pt, equal to 5·08 °/₀ N.

4. 0·2644 burned do. gave 0·0979 Pt = 5·22 °/₀ N.

Mean in 100 parts.		Quot. by At W.	Quot. by N.
C	64·89	5·4075	14·70
H	8·335	8·3350	22·66
N	5·15	0·3678	1·00
O	21·63	1·3518	3·67

Formula C_{15} H_{23} N O_3.

Synopsis of Formulæ of Omicholine and Omicholic Acid according to preparations.

B, *a.*	C_{24} H_{44} N O_6
B, *b.*	C_{16} H_{24} N O_4
C, *a.*	C_{22} H_{38} N O_4
C, *b.*	C_{15} H_{21} N O_4
D, *a.*	C_{22} H_{32} N O_5
D, *b.*	C_{15} H_{23} N O_3

Synopsis and Mean of Formulæ of Omicholine.

B, *a.*	C_{24} H_{44} N O_6
C, *a.*	C_{22} H_{38} N O_4
D, *a.*	C_{22} H_{32} N O_5
Mean formula of omicholine -	C_{22} H_{38} N O_5

Synopsis and Mean of Formulæ of Omicholic Acid.

B, *b.*	C_{16} H_{24} N O_4
C, *b.*	C_{15} H_{21} N O_4
D, *b.*	C_{15} H_{23} N O_3
Mean formula of omicholic acid	C_{15} H_{22} N O_4

APPENDIX.

No. 6.
On Chemical Identification of Disease, by Dr. Thudichum.

Remarks.

These bodies are evidently well-defined different entities, although they have not yet been obtained in a pure state. They differ from each other, but cannot yet perhaps be absolutely separated from each other. On the other hand, they have so many properties in common, that the one may possibly be derived from the other, or that both may have a common origin. They are both obtained by boiling the watery solution of isolated urochrome with acid, and are therefore probably derivates of urochrome. Their molecular weight has not yet been determined, as no compound appeared definite enough for that purpose.

Importance in kidney diseases.

The importance of these bodies in pathology may be inferred from the fact that they are capable of forming in the human body in certain forms of kidney disease. The breath and the exhalation of the skin in such cases smell strongly of omicholine and omicholic acid. Their nauseous and emetic properties, already observed by Proust, may perhaps contribute to the explanation of that peculiar vomiting which occurs in cases of chronic kidney disease, in which dropsy and œdema have naturally, or by the constant use of the Turkish bath, ceased to be factors of the pathic process.

As it will, perhaps, be many years before (if ever) I can resume this research, and carry it to that completion which I strongly feel it wants, but which the time and materials at my command did not permit me to give it, I must hope that others will supply the desired information. They should extract the materials from several thousand gallons of urine in order to obtain quantity sufficient for all purposes. The quantity of omicholine and omicholic acid which can be obtained from lesser quantities of urine is indeed not small; but of the mixed resins obtained so much is lost in the various processes of purification, that what remains is the lesser portion, and insufficient for that varied analysation and testing which uncrystallisable and uncombinable substances more than any others require.

F.—*Uropittine.*

Synopsis of Preparations of Uropittine.

A. I.
A. II. } Three elementary analyses. Uropittine perhaps a stage between urochrome and uromelanine.
Meta-uropittine. Urorubine.
A. III. From putrid urine. In store.
B. I.
B. II.
B. III.
C. I.
C. II. } Six preparations obtained, three from each, used and analysed as in special list.
D. I.
D. II.
D. III.
D. IV. } Hypothetical silver-uropittate, from supposed uromelanine.

Uropittine, A. I. and A. II.

The uropittine described in the Hastings Prize Essay had yielded on analysis the

	Mean in 100 parts.	Quot. by At. W.	Quot. by N=1.
C	55·25	4·604	5·32
H	5·57	5·570	6·44
N	12·10	0·864	1·
O	27·08	1·687	1·952

If the latter quotients are multiplied by 7, the number of nitrogen atoms in uromelanine, we obtain uropittine $= C_{37}\ H_{45}\ N_7\ O_{11}$. From

this formula that of uromelanine could easily be derived by assuming that uropittine takes up two atoms of oxygen, and loses one molecule of carbonic anhydride and one molecule of water.

$$\underbrace{C_{37}\,H_{45}\,N_7\,O_{11}}_{\text{Uropittine.}} + \underbrace{2O}_{\text{Oxygen.}} = \underbrace{C_{36}\,H_{43}\,N_7\,O_{10}}_{\text{Uromelanine.}} + \underbrace{CO_2}_{\text{Carbonic acid.}} + \underbrace{H_2\,O}_{\text{Water.}}$$

In that case the atomic weight of uropittine would be 763.

It is unquestionable that the urochrome, as well during the chemolytic, as more particularly during the physiolytic process of decomposition, absorbs oxygen. During the operations accompanying the separation of uromelanine, much matter, soluble in alcohol and having the properties of uropittine, is gradually transformed into uromelanine. The above process may therefore express more than a speculative formula.

Meta-uropittine from Spec. A.

This body resembles uropittine in composition, but differs by being easily soluble in alcohol. It does not fuse in heat. After extraction of matters soluble in ether alcohol easily dissolved this matter. It was precipitated by water, washed and dried at 100° C. It was much less in quantity than urorubine, to be described below.

Analyses: 1. 0·3335 grm. burned in lead chromate gave CO_2 = 0·6554 or 53·59 °/o C and H_2O = 0·1947 or 6·48 °/o H.

2. 0·2645 grm. gave CO_2 = 0·5376 or 55·43 °/o C and H_2O = 0·1566 or 6·57 °/o H

	Mean of analyses.	Uropittine A. I. and II.
C	54·51	55·67
H	6·52	5·15

The substance therefore contains more hydrogen than the preparation from A. I. and II. by its side. Possibly it may be a substance which is yet before uropittine or urorubine in its transformation towards uromelanine. Its existence and empirical composition are here noted in order that future researches may refer to it and decide whether it is a transition product or a mixture.

Urorubine from Spec. A.

It had been separated from the uropittine described and analysed in the Hastings Prize Essay. It was easily soluble in cold absolute alcohol, and stood for three months in it to deposit body less soluble (Uropittine). It had then been precipitated by water, filtered and dried in vacuo. It was very hygroscopic, and after drying at 100°, when it did not fuse, always gained from two to three milligrammes under the dryer. After three days of labour the last weighing was assumed as practically correct.

Analyses: 1. 0·2448 grm. burned in chromate gave CO_2 = 0·5808 or 64·70 °/o C and H_2O = 0·1515 or 6·87 °/o H.

Deducting from the substance 0·0028 grm. of weight, which if it was not oxygen might possibly have been adventitious water, we get urorubine = 0·2420; CO_2 = 0·5808 or 65·45 °/o C and $H_2\,O$ = 0·1487 or 6·82 °/o H.

2. 0·2035 burned with chromate gave $\cancel{CO}_2$ = 0·4852 or 65·02 °/$_0$ $\cancel{C}$ and $H_2\cancel{O}$ = 0·1266 or 6·91 °/$_0$ H.

3. 0·3082 burned with soda-lime gave 0·2492 grm. $\cancel{Pt}$ equal to 11·46 °/$_0$ N.

It is preferable not to assign a formula to this body at present. It contains more carbon than either uromelanine or uropittine, and could be considered as a body less oxydised than either of these two, and standing nearer to urochrome. It contains more than double the amount of nitrogen which is contained in omicholine or omicholic acid.

Hypothetical Silver-Uropittate from D. IV.—An ammoniacal extract from uromelanine D. IV. by evaporation and resolution in water was precipitated with silver nitrate, boiled, filtered, and washed with water. Washings were almost colourless, and free from silver. Dried in steam-closet, afterwards in air-bath at 110°,

(1.) 0·1501 burned left 0·0487, or 32·44 °/$_0$ Ag.
(2.) 0·1046 do. do. 0·0336, or 32.28 °/$_0$ Ag.

Thereupon another preparation was made in exactly the same manner, and yielded,

(3.) 0·1326 grm. left 0·0426, or 32·12 °/$_0$ Ag.

The salt was therefore surmised not to be a uromelanate, but to stand nearer to the uropittates with 38·71 (C, α, 3), and 35·49 °/$_0$ of Ag.

I look upon these and like analyses as merely tentative. When the same process applied to the same preparation yields the same compound, this constitutes a symptom in favour of the supposition that the compound is definite, *i.e.*, in atomic proportions. By producing a great many such compounds under varying conditions, those which conform to atomic laws are easily found out by their repetition. If instances remain isolated their accidental and non-specific nature is proved. I consider this proceeding the only one which in the present state of our knowledge of these matters can be applied for the obtaining of the precise information which is so urgently required.

Further Treatment of the mixed Resins C.

(*C.*) *Extraction with Alcohol.*

Cold alcohol extract.

The mixed resins, after having been exhausted, first with cold then with boiling ether, were treated with cold alcohol, and the dark solution was filtered. The filtrate (sol. α) after having stood some time had formed a deposit, and was therefore again filtered. A dark brown powder (designated as uropittine, specimen α, 1) remained on the filter.

Precipitate by ether.

The mother liquor (sol. α) was mixed with ether. It deposited a quantity of flaky light brown matter which after resolution in alcohol gave two specimens, which were designated specimens α, 2, and α, 3.

Hot alcohol extract.

The residue, which had been insoluble in cold alcohol, was now boiled with alcohol and filtered hot on steam funnel (solut. β) No deposit formed on cooling, but on first concentration a deposit, specimen β, 1, formed. On second concentration it deposited specimen β, 2. The mother liquor was evaporated to a syrup and mixed with five volumes of ether. It deposited a flaky light brown matter, β, 3.

Insoluble residue, Uromelanine.

After countless alcohol extractions there remained an insoluble residue (it imparted a colour to boiling alcohol, but the quantity dissolved was imponderable). It was dissolved in ammonia, precipitated by $H_2\cancel{S}\cancel{O}_4$, washed with water, treated with alcohol, dissolved in ammonia, and evaporated to dryness. By its properties, and the analysis

of a silver salt of it, it was found to be mainly *uromelanine*. For the watery extract of the dry residue (of which the greater part remained undissolved in the water, as is usual with uromelanine) on being treated with silver nitrate, boiled, filtered, and washed, gave the following results to analysis. Dried at 110°.

1. 0·1476 grm. left 0·0198 grm. or 13·41 °/₀ of Ag.
2. 0·1550 grm. left 0·0212 grm. or 13·67 °/₀ Ag.
3. 0·3458 grm. burned with soda-lime left 0·2662 Pt, equal to 10·91 °/₀ N.

Neutral silver uromelanine, C_{36} H_{40} Ag N_7 O_9 requires 13·13 °/₀ Ag, and yielded in the mean 13·47, which is almost the same as the foregoing mean 13·54 °/₀ Ag. Nitrogen required, if one H_2 O leaves the salt 11·92, found formerly 12·47. If no water leaves the neutral silver salt, it requires 11·66 °/₀ N.

Uropittine; Specimen C, α 1.

Ba salt.

The substance was dissolved in ammonia and the alkaline solution treated with Ba Cl_2. Precipitate washed and dried at 110° C.

0·1204 gave 0·0414 Ba SO_4, equal to 20·21 °/₀ Ba.

Note. - Similar Ba salt obtained from omicholic acid.

Note.—A quantity of omicholic acid (Specimen B) in ammonia was treated with Ba Cl_2. After treatment like the precipitate from C, b, a compound was obtained, of which dried at 95°

0·3664 gave 0·1069 grm. Ba CO_3 equal to 20·28 °/₀ Ba.

This would therefore amount to a proof that omicholic acid, when it yields a precipitate with barium salts, contains uropittine. By the compound C, b, α, this proof was not definitely afforded.

It was also essayed to prepare a Ba salt from a neutral solution, but the quantity ultimately obtained was too small for analysis.

Uropittine Silver from Specimen C, α, 1.

Ag salt, 21·39 °/₀ Ag.

Uropittine (C, α, 1) dissolved in concentrated ammonia was evaporated to dryness. Of the residue a small part only dissolved in water, the greater part remained undissolved. Silver-nitrate was added and the mixture boiled. The precipitate was washed on the filter until the filtrates were free from silver and colourless.

1. 0·2412 grm. left 0·0510 grm. or 21·14 °/₀ Ag.
2. 0·1118 grm. left 0·0242 grm. or 21·64 °/₀ Ag.

Mean. 21·39 °/₀ Ag.

3. 0·1194 grm. burned in soda-lime, &c., gave 0·1033 Pt equal to 12·27 °/₀ N.

Bearing with Ammonia of Specimen C, α, 1.

The uropittine was dissolved in ammonia, the solution evaporated to complete dryness, and the salt redissolved in water. To the solution (a part remained undissolved) hydrochloric acid was added, whereby the uropittine was precipitated. The latter was collected, washed, and dried at 100° upon a weighed filter.

Dry uropittine = 0·1003 grm.

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The acid filtrate yielded chloride of ammonium, which by the usual treatment left 0·081 grm. of Pt. This yields upon 100 uropittine 13·90 parts of ammonia, or in 100 parts of compound 87·8 uropittine and 11·20 °/₀ ammonia.

This is more than a molecule of ammonia for even a small formula of uropittine. Indeed as only a part retains ammonia, another becomes insoluble, the instability of the compound is proved. But it is interesting that even in a solution so treated there may be more than a quantity of ammonia necessary to produce a neutral salt. It must, however, not be forgotten that the quantities of material employed were very small.

Uropittine C, α, 2.

This substance was precipitated by ether from the solution in absolute alcohol of the mixed urinary resins. It was dried at 100°, and did not become soft.

1. 0·1596 grm. burned in lead chromate, ultimately in oxygen, yielded 0·3529 CO_2 and 0·0904 H_2O, equal to 60·30 °/₀ C, and 6·29 °/₀ H.

2. 0·2215 grm. burned in lead chromate without the employment of oxygen gave 0·4865 CO_2 and 0·1405 H_2O, equal to 59·90 °/₀ C and 7·04 °/₀ H.

3. 0·2346 grm. burned with soda-lime, &c., gave 0·1727 Pt, equal to 10·44 °/₀ N.

4. 0·2789 grm. burned, &c., gave 0·2066 grm. Pt, equal to 10·50 °/₀ N.

Synopsis of Analyses.

	1.	2.	3.	4.	Mean.
C	60·30	59·90	,,	,,	60·10
H	6·29	7·04	,,	,,	6·66
N	,,	,,	10·44	10·50	10·47
O	,,	,,	,,	,,	22·77
					100·00

Uropittine Silver.

From Prep. C, α, 3 (boiled preparation).

The specimen of uropittine used for the preparation of this salt was precipitated by ether from an alcoholic solution of mixed urinary resins. It was dissolved in ammonia. To the solution some more uropittine was added in order to ensure its neutrality; thereupon it was precipitated by silver nitrate. After having been boiled, a proceeding which was necessary to cause the immensely voluminous precipitate to contract, it was collected on a filter. It appeared of a dark green colour, while the mother liquor was slightly yellow. The washing liquors were of a darker colour than the mother liquor, and fluoresced strongly. Dried at 110°,

1. 0·2115 left 0·0818 grm. of Ag., or 38·67 °/₀.
2. 0·1837 left 0·0712 grm. or 38·75 °/₀.

Mean of these analyses is 38·71 °/₀.

This leads to 279 as the atomic weight of the salt, and 172 as the atomic weight of the organic residue (Ag. = 108). This is very near to the molecular weight of hippuric acid ($C_9 H_9 NO_3$) = 179; but it is not conceivable that this acid should be precipitated by ether, and be insoluble in water, except after having undergone great and peculiar alterations.

3. 0·3241 grm. burned with lead chromate gave 0·4340 CO_2 and 0·1164 H_2O, equal to 36·52 °/o C and 3·99 °/o H.

4. 0·2919 burned with soda-lime, &c., left 0·1430 grm. Pt, equal to 6·94 °/o N.

Synopsis of Analyses.

	1.	2.	3.	4.	Mean.
C	,,	,,	36·52	,,	36·52
H	,,	,,	3·99	,,	3·99
Ag	38·67	38·75	,,	,,	38·71
N	,,	,,	,,	6·94	6·94
O	,,	,,	,,	,,	13·84
					100·00

Uropittine Silver. Second preparation from C, α, 3.
(Not boiled.)

Uropittine obtained by ether from alcoholic solution of mixed resins, and purified by solution in ammonia and subsequent precipitation by hydrochloric acid, was again dissolved in a few drops of ammonia, and the solution made as neutral as possible by digesting it with an undissolved excess of uropittine. The filtered solution was precipitated by silver nitrate, and the precipitated silver-uropittate was collected on a filter and washed. The mother liquor and the filtrates were colourless. The precipitate was dried at 110° C.

Uropittine silver. Not boiled.

1. 0·2150 grm. left 0·0770 grm. or 35·81 °/o Ag.
2. 0·2402 grm. left 0·0845 grm. or 35·17 °/o Ag.

Mean of these analyses 35·49 °/o Ag. leading to 304 as the Mol. W. of the salt, and 197 as M. W. of uropittine.

3. 0·3144 burned with lead chromate left 0·4375 CO_2 and 0·1216 H_2O, equal to 37·95 °/o C and 4·29 °/o H.

4. 0·2708 burned with soda-lime, &c., left 0·1260 Pt, equal to 6·59 °/o N.

5. 0·2345 gave 0·1058 Pt, or 6·39 °/o N.

Synopsis of Analyses.

	1.	2.	3.	4.	5.	Mean.
C	—	,,	37·95	,,	,,	37·95
H	—	,,	4·29	,,	,,	4·29
Ag.	35·81	35·17	,,	,,	,,	35·49
N	,,	,,	,,	6·59	6·39	6·49
O	,,	,,	,,	,,	,,	15·78
						100·00

The preceding shows that the former preparation was probably decomposed (oxydised) by the boiling of the precipitate. This effect is

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well known to occur in many silver-salts. It washazar ded in this instance because it had been found that the uromelanine-silver salts bear boiling without changing in composition.

Uropittine Barium.

Uropittine Barium, from C, α, 3.

It was attempted to produce a barium salt. The uropittine was obtained by precipitation with ether from an alcoholic solution of mixed urinary resins. It was dissolved in ammonia, and barium chloride added to the slightly ammoniacal solution. The mother liquor after filtration was dark coloured, but the washing water became constantly lighter, until it appeared only slightly yellowish at last. Although 0·5 grm. of uropittine had been dissolved, only 0·1605 grm. of barium salt were obtained.

Only analysis: 0·1605 grm. gave 0·0194 grm. Ba SO_4, equal to 7·10 % Ba.

Uropittine-barium is therefore not insoluble in water. However 7·10 is near 7·20 % Ba, which was found in dibarytic penta-uromelanine ($\tilde{U}r_5\,Ba_2$). Possibly, therefore, the uropittine might have contained thus much of uromelanine (still soluble in alcohol). It is, however, evident that from such extremely needy data no opinion can properly be formed.

Uropittine, Specimen C, β, 1.

Ca salt.

It was attempted to produce a neutral solution of this body by evaporation of its ammonia solution. By addition of Ca Cl_2 was produced:

Uropittine Calcium.

Analyses: 1. 0·2069 grm. gave 0·0128 $CaSO_4$ equal to 1·81 % Ca.

„ 2. 0·1944 grm. gave 0·0116 $CaSO_4$ equal to 1·75 % Ca.
Mean 1·78 % Ca.

„ 3. 0·1840 grm. yielded 0·1578 grm. Pt, equal to 12·16 % N.

If uropittine had a composition and atomic weight close to that of uromelanine, this compound might be considered as containing 3 $\tilde{U}r$: 1 Ca. This compound would require 13·13 % of N. But if uropittine have a smaller molecular weight, the figures found for Ca lead to no acceptable formula. They show no parallelism to the Ba salts above described. A zinc salt 3 $\tilde{U}r$: 1 Zn. is amongst the compounds observed.

Uropittine, Specimen C, β, 2.

Ba salt from alkaline solution.

It was dissolved in a slight excess of ammonia, Ba Cl_2 added, and dried at 110°.

0·2560 gave 0·0948 Ba SO_4, equal to 21·77 % Ba.

Ba salt from neutral solution.

A solution of uropittine in ammonia was evaporated to dryness, and the residue treated with water. A part dissolved an another remained insoluble. To the solution Ba Cl_2 was added, which produced a flaky precipitate. This was collected on the filter and washed until the

filtrates were free from Ba. The last filtrates were slightly coloured but free from Ba. The bulky precipitate shrivelled to an insignificant amount during drying in the steam oven, and could not be separated from the paper sufficiently clean to be analysed.

Silver Compound of this preparation.

Ag. compound, 27·14 % Ag.

It was dissolved in ammonia and the solution evaporated to dryness. Of the residue only a small part dissolved in water, the rest remained insoluble. Silver-nitrate was added and the mixture boiled. The precipitate was washed upon the filter until the filtrates were colourless and free from silver. Dried at 110° C.

1. 0·1628 grm. left 0·0442 grm. or 27·14 % Ag.

The same Silver Compound obtained from another pure specimen of Uropittine, C, β, 3.

Same Ag. compound.

The uropittine had been precipitated by ether from an alcohol solution. It was dissolved in ammonia, evaporated, and precipitated by silver-nitrate. The washed precipitate, which had not been heated, was dried in vacuo over sulphuric acid, light being carefully excluded. It formed a glistening, blackish, violet brown mass.

0·346 grm. left 0·0937 grm. or 27·0 % Ag.

G.—*Researches on the Derivates of Hematocrystalline, the Colouring Matter of Blood, continued.—On Hematine, continued.*

Mode of obtaining from alcoholic blood-cake by tartaric acid.

a. A quantity of blood containing the colouring matter, which had been precipitated by alcohol, was mixed with carbonate of potash, and afterwards digested on a steam bath with a large proportion of alcohol. A deep red alkaline solution was obtained. To this an alcoholic solution of tartaric acid was gradually added, until the red precipitate at first thrown down redissolved to a certain extent. Thus the colouring matter was separated from the albuminous matters; the former was redissolved, the latter stained brown remained as a precipitate insoluble in the acid fluid. The liquid, which now consisted of an acid solution of hematine and some impurities, was evaporated at a temperature not exceeding 75° C. to about one-tenth of its bulk. A minute quantity of black crystals of microscopic dimensions separated on the liquid cooling, together with some fatty matters and small crystals of cholesterine. Various proceedings were adopted to purify the substance, but they failed to give the results required.

b, by oxalic acid.

b. The blood-cake was then pounded with oxalic acid, and the mixture digested with alcohol.

c, by sulphuric acid.

c. It was also extracted by means of alcohol and a little sulphuric acid.

Both proceedings *b* and *c* gave materials which were too impure to warrant further treatment.

d, by potash, tartaric acid, and alcohol.

d. Three gallons of blood were treated with seven times their bulk, *i.e.*, 21 gallons of a cold solution of potash carbonate, containing one part by weight of the salt in two parts of water. A thickish soup-like mixture resulted, which was filtered on square pieces of calico extended over a frame. The filtrate was not nearly colourless. The precipitate was tied up in the calico filters and pressed, gently at first, and more

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tightly afterwards, until all the liquid was pressed out as much as possible. The compressed cakes were then treated with alcohol, and the carbonate of potash solution which separated on standing was poured off. The residue was then again well pressed, and now formed consistent cakes. These were crumbled and dried at the ordinary temperature by standing spread out in flat basins. This material was now triturated with warm absolute alcohol, and then digested with a large quantity of the same at a temperature not exceeding 40° C. The solution was filtered off and then treated with an absolute alcohol solution of tartaric acid. The potash was thus precipitated and the hematine remained dissolved. Enough acid was added to cause the liquid to show a decidedly acid reaction when the litmus paper first dipped into the alcohol was moistened with water. After about a third of the bulk of the liquid had been evaporated below 40° C, all the hematine was deposited on cooling in very minute bluish-black crystals. By further evaporation not much more hematine was gained, and what little deposited was exceedingly impure, resembling a brown fatty matter. This matter was soluble in alcohol, insoluble in water, was attacked by nitric acid and yielded a colourless solution.

Hematine crystals.

The hematine crystals were rhombic plates. They grouped themselves frequently with their edges upwards, so as to resemble clusters of needles. They were filtered off on a very close paper filter, washed with water and absolute alcohol. The microscope revealed the presence of slight traces of foreign matters, which it was determined to remove by recrystallisation.

H.—*Intermittent Hæmaturia, s. Hematinuria, s. Cruenturesis.*

Intermittent cruenturesis.

There is a rare form of disease, which has been described by a number of observers, but more particularly by Dr. E. H. Greenhow in a learned and instructive article in Edinb. Med. Journ., May 1868. He says that in all the cases which he has seen of this disease the attacks have been excited by the same cause, have taken the same form, exhibited the same general group of symptoms, and run the same definite course. The immediate exciting cause of the attacks has been invariably some definite exposure to cold or wet. The form taken by the attacks has been invariably that of paroxysms; these coming on suddenly, almost immediately after the chill was experienced, and passing off rapidly when the effects of the chill had been counteracted and the patient had become thoroughly warm. The general group of symptoms has been invariably the same, the additional ones occasionally exhibited being apparently due to an unusual degree of constitutional disturbance. In every instance the paroxysms have begun with coldness of the extremities, followed by general chilliness, amounting in the severer attacks to rigors. In like manner, in every case, the chilliness or shivering has been attended by a feeling of weight and pain in the loins, and by pain or a sense of weakness or stiffness in the lower limbs. The chilliness has been usually, though not always, followed by an imperfectly marked febrile hot stage. The patients have invariably passed, during the paroxysms, urine looking as if it were mixed with blood, and identical in general character. And lastly, the same definite course has been run by the paroxysms in every case. From half an hour to two hours after the chilliness or rigors the patient has never failed to pass the first dark-coloured urine, which has always been highly albuminous, and has contained numerous crystals of oxalate of lime, with more or less of brownish or yellowish red, amorphous granular matter,

and a few hyaline casts, but only occasionally some stray blood corpuscles. At each succeeding micturition after the chilliness, the urine has invariably shown more or less diminution of colour, of albumen, of oxalate of lime, and of its other abnormal constituents; resuming its natural character and appearance by the second or third micturition after slight attacks, and usually by the fourth or fifth after severer paroxysms. By the second day after an attack the patients, as a rule, have regained their ordinary degree of health and strength, and have continued well until some fresh exposure has brought on a new attack of their complaint. Most of the patients suffering from this disease have had the same pale, sallow, cachectic aspect, two of them having been distinctly jaundiced, and the others having all had at times an icteroid tint of skin.

Thus it appears that intermittent hematuria is a definite disease, due in all cases to the same remote constitutional cause. The only medical treatment which appears to have any effect in diminishing the liability to suffer from the paroxysms on every exposure, is treatment directed, during the intervals, towards the improvement of the general health and the strengthening of the patient's constitution. Once the paroxysms have set in, the most simple means of restoring warmth are all that it is advisable to use. The short duration of the paroxysms, the very general absence of blood corpuscles from the urine, even at the time of the paroxysms, and the complete recovery of the normal character of the urine within a few hours after their subsidence, seem to show that there can be no cause of hæmorrhage in the kidneys themselves, but rather that the disintegrated blood traverses through the walls of the blood vessels in the Malpighian bodies. For this reason Dr. Greenhow regards the kidneys rather as the organs of elimination than as the seat of the disease, and considers the renal irritation, the existence of which is manifested by the pain in the loins and by the presence of the casts, and occasionally also of stray blood corpuscles in the urine, to be a secondary affection consequent upon congestion of the kidneys produced by the sudden and unusual strain thrown upon them. Possibly the paroxysms may consist in the sudden disintegration of an unusually large quantity of blood corpuscles, setting free so considerable an amount of hemato-globuline that it cannot undergo the normal changes, but is eliminated through the kidneys in a comparatively unaltered state.

Amongst the English medical authors who have related cases of intermittent or paroxysmal hematuria, are, besides Dr. Greenhow, Sir Thomas Watson, Dr. Elliotson, Dr. Prout, and more recently Dr. G. Harley, Dr. Dickinson, and Dr. Gull. Several of these authors have considered the disease to be of malarious origin, and there is no doubt that in some of the cases published the patients had also suffered from ague. But on the other hand, not one of Dr. Greenhow's patients had suffered from ague, and some of them at least had never visited a malarious district. The same absence of malarious influence has been noted by Dr. Pavy and Dr. Murchison in cases published by them in the Pathological Transactions. The disease in fact merely resembles ague in its intermittent form, and in its commencement with rigors, which are followed, however, by only an imperfect hot stage and rarely by a sweating stage. It differs from ague in not being periodical, and in requiring, apparently, a fresh exposure to cold or damp to excite each separate paroxysm. The history of most of the cases seems clearly to indicate the existence, in all the patients, of some sort of dyscrasia, upon which the external chill acts only as the immediate exciting cause of the paroxysm. Many patients suffer from so-called rheumatic pains

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during the paroxysms. Some patients suffered from such pains at all times, but this was probably due to secondary syphilis with which they were afflicted at the same time. No post-mortem examination has ever been made of any case.

Spectroscopical and chemical examination of the urine.

Spectroscopical and Chemical Examination of the Urine.—The urine, which had been kindly forwarded to me by Dr. Greenhow, was about an ounce and a half in quantity, of a brownish red colour, and turbid by a brownish red precipitate. This was filtered off, and by testing shown to be hematine in the same state as the hematine which is precipitated by acetic acid from a watery solution of blood on standing.

The filtrate was now more red than brown, clear, and port wine red in transmitted light. In a layer of $1\frac{3}{4}$ centimetres in thickness it had spectrum—

1. 39 to 49 = 10; int. 8; R. α.

Greenish yellow interval.

2. 56 to 65 = 9; int. 10; R. β.

Cut off at 68. The interval from 65 to 68 is shaded to intens. 3, and appears reddish.

In a layer of one centimetre in thickness the following spectrum was developed:—

1. 40 to 46 = 6; int. 4; R. α.
2. 57 „ 64 = 7; „ 3; „ β.
3. 72 „ 82 = 10; „ 5; „ γ.

Cut off from 87; though continuation seems to be illuminated.

Diluted + 1 water, 1 ctr. thick.

1. 41 to 47 = 6; int. 3; R. α.
2. 58 „ 64 = 6; „ 2; „ β.
3. 72 „ 82 = 10; „ 3; „ γ.
4. 88 „ 110 = 22; „ 5; „ δ.

Violet blue cut off at 141.

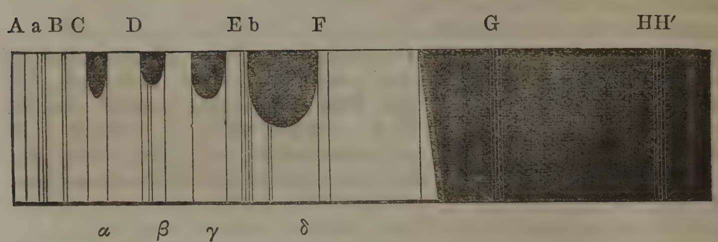

Diagram of Spectrum of Urine in Intermittent Hematuria.

At first sight this spectrum offered a remarkable similarity to that of cruentine described in the Appendix to the 10th Report. It was, however, clear from chemical reaction that cruentine could not be present. By boiling of the urine the entire amount of colouring matter was coagulated, and from the coagulum alcohol and sulphuric acid extracted hematine only. This pointed to hemato-crystalline, with the spectrum of which the bands β and γ nearly coincided.

The bands α and δ then appeared to coincide with two of the bands of hematine in acid solution. By measurement this was found to be nearly the case.

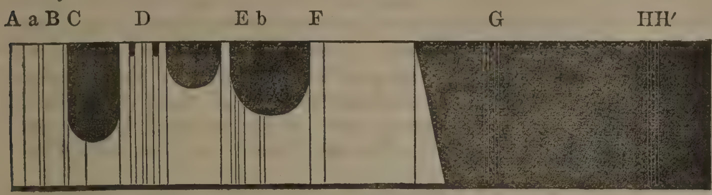

Diagram of Spectrum of Acid five-banded Hematine in Alcohol.

The urine was now treated with a reducing solution of sulphate of suboxide of iron in tartrate of ammonia with excess of this alkali, when the four bands immediately disappeared, and one broad band was present in their place.

1. 55 to 82 = 27. Int. 6.
Rest very dark. Cut off at 110.

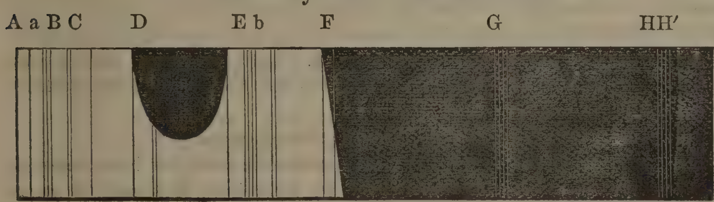

Diagram of Spectrum of Urine treated by reducing Fluid.

By violent shaking with air the broad band disappears, and the former bands do not reappear. The fluid is extremely turbid, and there remains even on dilution with water a very faint continuous spectrum without any bands. Nevertheless it is clear that the reaction of reduction indicates the presence of hematocrystalline as well as of hematine, as a comparison of the spectra of these substances in the reduced state with the spectrum just given will show.

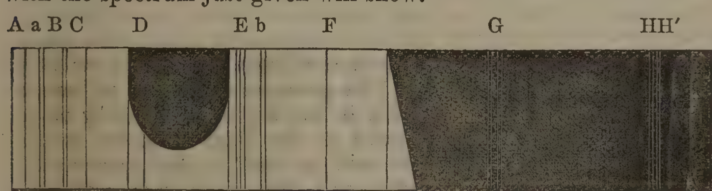

Diagram of Spectrum of reduced Hematocrystalline.

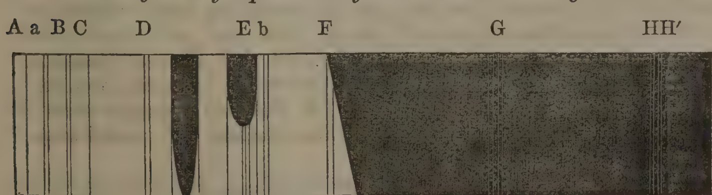

Diagram of Spectrum of reduced Hematine.

It will be seen from these spectra that the bands of reduced hematine and hematocrystalline necessarily coincide, so that the separation of the

bands of reduced hematine cannot appear, just as in the original spectrum of the urine the bands 2 and 3 of four-band hematine, or the bands 2, 3, and 4 of five-band hematine, coincide with the two bands of hematocrystalline. All facts therefore show that hematocrystalline and hematine in about equal proportions are present in the urine in question, and the only anomaly, which may perhaps yet be explained by the complex character of the fluid, is that on shaking with air of the reduced fluid, although the one band disappeared, none of the original bands reappeared. Somehow or other the substance had been changed by this operation.

The urine was extremely acid, and the excess of acidity seemed to be due to a volatile organic acid, probably *acetic*. On standing the urine gradually deposited a flocculent brown precipitate of hematine, and the bands of hematine in the spectrum became "pari passu" much paler, while the fluid became redder. The same bearing was observed in a mixture of watery blood with a little acetic acid. During my researches on cholera I also once observed an extract from muscle present the same spectrum as the above urine, but not having powerful light at my command I was unable to follow the observation in all its details. The extract from muscle also contained some acetic acid, and on comparison of the spectrum then observed and measured I have no doubt that it was due to the presence of a mixture of hematine and hematocrystalline (myochrome).

Conclusions.

These observations lead to the following conclusions :—

1. The urine in so-called paroxysmal hematuria contains hematocrystalline and hematine in solution. 2. The hematine also occurs as a precipitate which increases on standing. 3. There is no proof of the presence of dissolved albumen apart from the coagulable hematocrystalline (see, however, 5). 4. It is probable that in this disease a small quantity of blood is somehow or other dissolved, *e.g.*, by bursting of a Malpighian glomerulus, and mixing of the blood with effused urinary water, or by other means. 5. The hematocrystalline so effused is in part transformed into hematine (and some other body, possibly albumen, in a precipitated flocculent form), which for a time remains dissolved in the fluid, but is gradually deposited in the insoluble form. 6. This transformation is probably due to the morbid evolution in a certain part of the kidney of a quantity of organic acid, possibly acetic acid, which dissolves the hematine and imparts to the urine an unusual and very high morbid degree of acidity. 7. The presence of oxalate of lime in the urine is no great anomaly, but if it has any significance by being present in large quantity would point in the same direction as the presence of acetic acid. 8. Acetic acid by itself is also no anomaly, it being a normal ingredient of urine, as I shall show in an extensive research to be published on a future occasion. 9. But its presence in a concentrated form in a certain part of the kidney-tubes, where the other urinary constituents, notably urea, were not yet secreted and mixed with the hematocrystalline solution, so that it could transform a part of the effused hematocrystalline into hematine, is a great anomaly, and perhaps the essence of the disease. 10. Possibly the acid itself is the cause of the effusion of the blood, of its solution, and partial transformation.

I believe this to be the first instance in which hematine, hitherto known as an art-product of the laboratory only, has been proved to be present in an organic morbid fluid as the product of the diseased process itself. The name of "hematinuria" which has been proposed for the disease seems to me undesirable, because it would specify only one feature of the disease, and would unduly neglect the presence of hemato-

crystalline. Also "hematuria," being applicable to cases in which blood appears in corpuscles, does not appear to be a good denomination for the new disease. I would suggest "*cruenturesis*" (not cruentinuresis) as a suitable term; expressing the "*mictus cruentus*" without any attempt to define the particular coloured ingredients.

APPENDIX.

No. 6.
On Chemical Identification of Disease, by Dr. Thudichum.

I.—*On Cruentine, continued.*

In the report for 1868, I described a series of new derivates of hematocrystalline under the name of *cruentine*, and distinguished the several bodies from each other principally by names derived from their spectral phenomena. All the bodies thus described had been extracted from the original cruentine sulphate by means of alcohol, and were therefore either sulphates, or neutral, or made alkaline after extraction. But their common property was that of being soluble in alcohol. This solvent, however, left a large quantity of the original sulphuric acid product undissolved, even after many extractions at the boiling heat. To this insoluble part the following inquiries were directed. It was found that the boiling alcohol solutions on cooling deposited also this peculiar cruentine, which by itself was insoluble in alcohol, even on boiling. It is therefore soluble in the boiling alcohol solutions of the acid cruentates, but not in the cold.

Two-banded cruentine.

Two-banded Cruentine.—The substance left insoluble by the alcohol was a gelatinous light-red matter, of great volume, as was ascertained by a drying experiment. It was soluble in sodium carbonate, and showed a spectrum of two bands—

1. 60 to 74 = 14; int. 4; R. α.
2. 78 „ 92 = 14; „ 3; „ β.

When precipitated from this solution, and treated with an excess of hydrochloric acid in much water, a red solution is obtained, which can be diluted to any extent without depositing the cruentine. This has spectrum—

1. 60 to 72 = 12; int. 3; R. α.
2. 77 „ 92 = 15; „ 2; „ β.

Blue to 153, where spectrum is cut off.

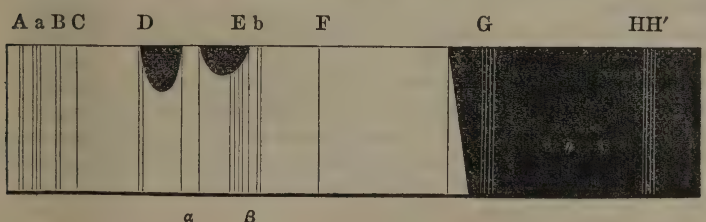

Diagram of Spectrum of Two-banded Cruentine in Hydrochloric Acid and Water.

This body has therefore intrinsically the same spectrum in alkaline as in acid solution, while all the other varieties of cruentine hitherto observed, as also hematine, change their spectra greatly when passing out of the alkaline into the acid state, or vice versâ.

Effect of reducing agents.

Effect of reducing Agents.—By the addition of ammoniacal tartrate of iron suboxyde sulphate the band β is much weakened, and all but disappears, but the band α is not much influenced, particularly no change in its position effected.

Reactions of hydrochlorate of two-band cruentine.

Reactions of Hydrochlorate of Two-banded Cruentine.—The cruentine was dissolved in sodium carbonate, and filtered; it was then precipitated by hydrochloric acid, washed by decantation and redissolved in water acidulated with hydrochloric acid. It was allowed to stand, when a slight turbidity of fat rose to the top, and another portion subsided; it was then filtered, and the solution in sodium carbonate and dilute acid was repeated until the substance was steady and uniform.

Pt Cl_4.

Platinum tetrachloride produced a precipitate in the solution, which contracted on boiling and remained insoluble in boiling alcohol. *The precipitate had the spectrum of two bands just like the original solution.* The filtered mother liquor had no spectrum. The deposits from the second, third, and fourth boiling alcohol extract of cruentine sulphate were purified as above, and combined with platinum for analysis.

Analyses.—1. 0·4305 grm. dried at 120° to 130°, on burning left 0·046 grm. residue, from which hydrochloric acid extracted 0·002 grm. iron oxyde. Pt = 0·044 or 10·22 °/₀.

2. 0·6625 of same preparation, left 0·075 residue, from which hydrochloric acid extracted 0·0055 grm. iron oxyde, Pt = 0·0695 grm., or 10·49 °/₀.

The mean 10·35 Pt leads, if the small quantity of iron, amounting to less than 1 °/₀, be neglected, to an atomic weight of 784. From a nucleus of this magnitude the molecular weight of uromelanine, 733, might easily be derived.

Hg Cl_2.

Mercury perchloride gave no precipitate even on boiling; the bands remained, and appeared remarkably like the blood spectrum. (It will be seen below that the solution by boiling for some time acquired the property of being completely precipitated by this salt.)

Cd Cl_2.

Cadmium chloride gave no precipitate, and the bands remained.

Cu acetate. Na and Zn acetate.

Copper acetate gave a precipitate containing all the cruentine; but as sodium acetate and zinc acetate also produce the complete precipitation of the cruentine, it is probable that acetates only act by displacing the solvent HCl, the free acetic acid being incapable of retaining the cruentine in solution.

$Fe_2\ Cl_6$.

Iron perchloride produces no precipitate, but intensifies the colour greatly, making it yellowish red.

NH_3.

Ammonia makes the pink solution dark red, and greatly intensifies the absorption of the spectral bands. In this ammoniacal solution—

Ca Cl_2. Ba Cl_2.

Ca Cl_2 and Ba Cl_2 produce precipitates on boiling, which are of light red colour, *and both show the two-band spectrum when exposed suspended in the fluid before the slit of the spectroscope.*

The barium compound was analysed:

(1.) 0·373 grm. left 0·0221 of residue, being barium-sulphate, and iron and copper oxyde, or 3·46 °/₀. Of this 0·0170 was the amount of the latter oxydes, leaving $BaSO_4$ = 0·0051, consequently it contained less than 1 °/₀, namely, only 0·8 °/₀ of Ba.

(2.) 0·6088 grm. left 0·0378 residue after treatment with $H_2\ SO_4$ = 3·64 °/₀. Of this 0·0302 was iron and copper oxyde, leaving only

0·0076 $BaSO_4$, equal to 0·73 °/₀ Ba. Mean of Ba found = 0·765 °/₀. This would lead to an atomic weight of 17908, which seems quite impossible. It is therefore clear that the Ba compound of two-banded cruentine decomposed during the washing with boiling water, to which the preparation, on account of its enormous bulk, had been subjected. Washing with cold water was found to be quite impracticable. The copper was derived from a copper still in which the alcoholic extraction had been made. The iron is a residue of that contained in the hemato-crystalline.

A second preparation, washed once by filtration, lastly by repeated decantation, being too gelatinous to admit of washing on the filter, gave—

(1.) 1·6616 grm. (became heavier during heating to 120°) left 0·0992 residue.

(2.) 1·2136 left 0·0696 grm. residue. When the copper was discovered the analysis was not followed out any further.

KHO.

Dissolved in caustic potash and alcohol, with a little sodium carbonate added, and allowed to stand for a week, two-band cruentine assumes the following elegant property. *Itself being red it fluoresces light green;* it yields a beautiful light green, of a pure and lively tint, when influenced by the light-cone collected from the sun by a quartz collimator. It reminds much of the phenomena of *omicholine* and *omicholic acid.* It retains the two bands, but they are more feeble, particularly the second band is almost like that obtained by reducing agents. This spectrum reminds also of omicholine.

Effect of boiling upon cruentine hydrochlorate.

Effect of protracted boiling upon two-banded Cruentine Hydrochlorate.—The object of this process was to ascertain whether the iron could be removed from the cruentine or not. The solution was boiled three days long. After two days boiling the spectrum of the solution was unchanged, but black matter was continuously deposited. *The acid filtrate* from the dark matter on the third day was dark red, and *was completely precipitated by mercury perchloride.* (In a solution of two-band cruentine in HCl sublimate produced a precipitate which dissolved on boiling. On cooling the solution gelatinized completely. On violent shaking the flakes separated and left the liquid colourless. There is therefore a third variety of cruentine, and of behaviour with mercury perchloride.) The precipitate had a curious dirty grey colour, and no red or brown about it.

Reactions of filtrate $HgCl_2$.

Potassium ferrocyanide produced a copious complete precipitate in the filtrate, all matter being deposited of a dark dirty greenish colour. The solution contains apparently much free iron, as the fluid above the precipitate deposits a second *blue* precipitate, Prussian blue. Sulphocyanide gave a red precipitate. Consequently the hydrochloric acid extracts iron and a little organic matter, to which sulphocyanide adheres. But the insoluble residue contained iron in quantity (also copper, if such had been added to the solution).

Ferrocyanide of potassium.

The hydrochloric acid solutions filtered from the deposit, and all the washing waters, were repeatedly evaporated to dryness, and left a black residue. This dissolved in concentrated H_2SO_4, and with alcohol this solution gave spectrum of two-banded cruentine sulphate. The fluid was very opaque. The water solution with caustic potash gave spectrum of four-banded cruentine. It contained great quantities of iron (and the impure specimen alluded to also of copper).

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The residue insoluble in HCl.

Cruentine made insoluble by boiling with Hydrochloric Acid.—The cruentine which had become insoluble in hydrochloric acid by boiling was washed with water. It remained insoluble in any kind of hydrochloric acid, concentrated or dilute, insoluble in ammonia, in alcohol, with or without acid or alkali. In its half-dried state it was, however, soluble in concentrated sulphuric acid. A mixture of a drop of this solution with alcohol gave the cruentine sulphate spectrum. The solution after standing 24 hours was poured into much water, and appeared almost completely precipitated. It was twice washed by decantation. The residue or deposit did not dissolve in concentrated or dilute hydrochloric acid, even on boiling, but dissolved easily in alcohol and a little HCl. It did not assume the two-band hydrochlorate spectrum of cruentine, but showed the sulphate spectrum—

1. 52 to 58 = 6
2. 61 „ 77 = 16

[Similarly a decoction with HCl of the precipitate from an alkaline solution of total cruentine (four-banded) which had been boiled during many weeks daily, showed not the two-banded hydrochlorate spectrum, but the sulphate with the narrow and wide band, the same as the foregoing. See measurements below.]

The addition of ammonia to the alcohol solution produced the *four-band cruentine spectrum.* A slight precipitate ensued in the solution which was probably an insoluble modification of the four-banded body.

Alcohol and HCl and dried two-banded cruentine.

Effect of Alcohol and Hydrochloric Acid upon dried Two-banded Cruentine.—The cruentine sulphate as before was boiled with alcohol to exhaustion, until nothing but the light red two-band cruentine, quite insoluble in alcohol on boiling, remained. This was dried and shrunk to a brownish red matter. It was slowly soluble in concentrated sulphuric acid on trituration and standing, and precipitated by water. It was also soluble in ammonia, but was partly deposited from this solution on standing by the evaporation of ammonia. (See *spectrum of deposit, below.*) It dissolved best in hydrochloric acid and alcohol, and the solution had the spectrum of cruentine sulphate.

1. 54 to 59 = 5 ; int. 1 ; R. β
2. 62 „ 79 = 17 ; „ 5 ; „ α

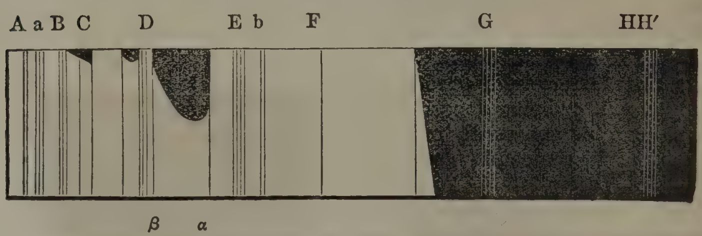

Diagram of the Spectrum of this Hydrochloric Alcohol Solution of Cruentine.

The greatest intensity of α is midway between 68 and 79, end at 142. The red is rather suddenly cut off, as if there was a band from 37 to 44. The foregoing spectrum is therefore identical with that of the hydrochloric product of cruentine described on p. 231 of Report, 1868. But there was this difference, that the solution after addition of ammonia

became *red when concentrated, green when diluted, and changed spectrum.*

1. 50 to 67 = 17; Int. 5; R. α
2. 75 „ 85 = 10; „ 1; „ β

Cut off at 110.

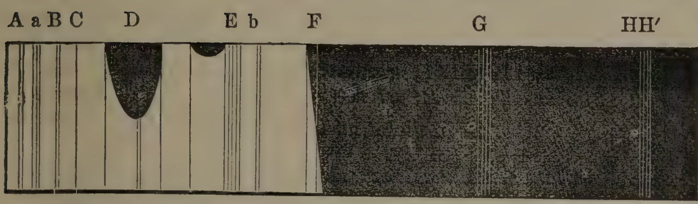

Diagram of Spectrum of Ammonia Solution of foregoing Body.

By reference forward it will be seen that this spectrum though similar to is not identical with the spectrum of two-banded cruentine hydrochlorate in water. When this latter solution is, however, made alkaline with ammonia it shows spectrum—

1. 54 to 68 = 14; Int. 5; R. α
2. 72 „ 84 = 12; „ 2; „ β

Cut off at 112.

Thus it is seen that this spectrum stands midway between the spectrum of acid watery and the ammoniacal alcohol solution.

Deposit from ammonia.

Deposit from Ammonia Solution of Two-banded Cruentine.—This deposit, which was obtained as above described, was redissolved in concentrated ammonia. It showed a spectrum of certainly four, possibly five bands, distributed as follows:

Band in red questionable.

1. 54 to 63 = 9; Int. 2; R. γ
2. 69 „ 77 = 8; „ 2; „ β
3. 85 „ 99 = 14; „ 3; „ α
4. 113 „ 127 = 14; „ 1; „ δ

Band No. 4 is in blue to indigo.
Cut off at 143.

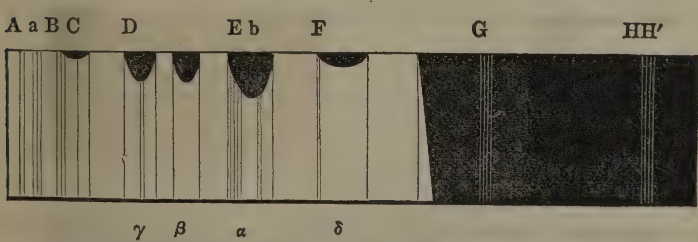

Diagram of Spectrum of Ammonia Solution of Deposit from Ammonia Solution of Two-banded Cruentine.

In case this experience should be repeated the red part of the spectrum will have to be examined in thicker layers of fluid. The band 4 or δ is quite peculiar to this body, no band having hitherto been found so far in blue with any preparation of cruentine.

Two-banded cruentine and hydrothion.

Two-banded Cruentine and Sulphuretted Hydrogen.—Cruentine was precipitated by soda from HCl solution and washed. It was then dis-

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solved in ammonia and the solution treated with hydrothion. It became very black coloured. On continued boiling it deposited all coloured matter together with black granules. Ammonia redissolved only a small portion, which had the same two bands as before. Even concentrated ammonia dissolved very little. Consequently the hydrothion had so far changed the cruentine as to make it insoluble in watery ammonia. The changed cruentine was, however, soluble in ammonia and alcohol, and formed a splendid red solution, which gave spectrum—

1. 63 to 74 = 11; int. 4; greatest on violet side; R = α
2. 80 „ 93 = 13; „ 2; even „ = β.

Cut off in violet at 150.

Diagram of Spectrum of Alcohol and Ammonia Solution of Two-banded Cruentine changed by Hydrothion.

On standing the dissolved matter became completely precipitated, and the alcohol almost colourless by loss of NH_3. The addition of a little NH_3 restored perfect solution. But after it had stood for one day the red matter had lost its solubility in alcohol with or without ammonia. Even boiling with these agents extracted only traces of matter, the iron had not been removed by the hydrothion. Concentrated sulphuric acid redissolved the matter and transformed it again into cruentine sulphate. This had the now well-known two bands in alcohol, but its watery solution treated with ammonia gave a precipitate, and after that was filtered off the solution showed spectrum of four-band cruentine.

Concentrated $H_2\,\text{S}\!\!\!-\!\text{O}_4$ and cruentine.

Effect of concentrated Sulphuric Acid upon Cruentine.—Cruentine had been dissolved frequently in concentrated sulphuric acid, it was at last dark brown. By frequent extraction with boiling alcohol of the precipitated and washed matter a soluble portion was extracted. The insoluble portion was dissolved in NH_3, filtered, evaporated to dryness, dried, and burned, and residue determined.

0·374 grm. product from cruentine dried at 125° left 0·019 $\text{Fe}_2\,\text{O}_3$, equal to 3·5 °/$_\circ$ Fe.

Alcoholic extract.

The alcoholic extract had a peculiar spectrum:

1. A broad feeble band. 49 to 74 = 25; int. 2; R. α

Blue shaded from 78 to 112, where the spectrum is cut off.

Diagram of the Spectrum of this Alcohol Solution.

The entire spectrum is very shady, though the red solution is quite clear. On dilution the band disappears before the shading in blue, and

the spectrum now reaches to 155. Diluted the red solution becomes brown; though still perfectly translucent it fluoresces with a smoky hue in diffuse sunlight; in the cone of the collimator it fluoresces strongly *in white with a tinge of greenish brown.* It differs completely from the fluorescent cruentine formerly described which becomes *red*, and shows the phenomena in a much feebler degree. The fluorescent body can in its power be compared only to solution of orchil (cudbear). The alcohol was evaporated, the residue dissolved in NH_3, filtered, evaporated, and the residue burned. It left red iron oxyde, which was almost insoluble in HCl.

Fluorescence.

Conclusions.

It was thus shown that cruentine cannot be deprived of iron by treatment with concentrated sulphuric acid and precipitation with water, even if continued so often that only enough material for one analysis is left. I believe that Lehmann never succeeded in obtaining hematine quite free from iron by this method, and I have never succeeded myself. I therefore believe that the statements of Mulder regarding hematine free from iron are as fallacious as his ideas regarding proteine free from sulphur. I found even that when copper salts or tin salts are mixed with cruentine, these metals follow the cruentine through all changes, and though a little may be lost at each change, there is always a quantity remaining in the ultimate cruentine.

Hemato-melanine.

Hematomelanine.—Thus I term the last product of the influence of sulphuric acid upon hematocrystalline and cruentine. It is purified by solution in ammonia, evaporation to dryness, and washing with water and alcohol. It is a black, shining matter, and burns with fusing and swelling, giving out much carbonaceous gas, which burns with strong yellow flame, greatly differing from the burning of uromelanine. It leaves a residue of iron oxyde.

Influence of sodium carbonate and boiling.

Influence of Carbonate of Sodium and boiling upon Cruentine.—The crude cruentine was dissolved in sodium carbonate and boiled for two days. After that it showed spectrum—

1. in red, feeble,	40 to 51	= 11;	Int. 1.
2. in yellow,	57 „ 71	= 14;	„ 3.
3. in green,	76 „ 89	= 13;	„ 5.

then darkness. More diluted the first band disappeared entirely, and there appeared band

4. 93 to 106 = 133; Int. 3.

The earlier alcohol extracts formerly described measured in spectrum—

1. 45 to	54;	Int. 1.
2. 63 „	75;	„ 3.
3. 79 „	92;	„ 4.
4. 98 „	115;	„ 3.

The soda had therefore hardly changed the cruentine.

After having been boiled daily during four weeks the spectral phenomena remained as above. It was precipitated by HCl and washed by decantation, during which it began to smell disagreeably, the weather being very hot. Treated with HCl in excess only a small portion of the substance dissolved, yielding apparently the cruentine sulphate spectrum (see below), not the two-banded hydrochlorate. Like another specimen which, boiled with HCl, smelled of glue and gelatinised, so this smelled of spoiled glue. The insoluble residue easily dissolved in alcohol, yielding four-band spectrum, feebly by itself, more strongly and better defined after addition of NH_3.

The circumstance that the sulphate spectrum was obtained instead of the hydrochlorate caused me to examine for sulphuric acid. The solu-

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tion was mixed with $BaCl_2$ and HNO_3, and allowed to stand two days, when a trace of barium sulphate had deposited. But the spectrum was apparently the same as before, only the first narrow band seemed much paler.

1. 49 to 58 = 9; Int. 1; R. β.
2. 61 „ 77 = 16; „ 5; „ α. The maximum of intensity is not in the middle, but has its axis at 73. Cut off in blue at 154.

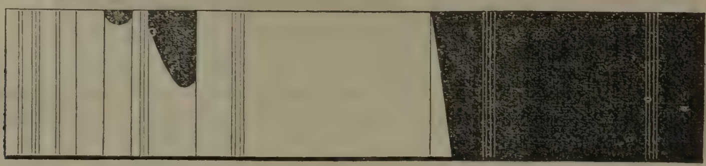

Diagram of this Spectrum of Cruentine Hydrochlorate in Alcohol.

Perhaps there is a shade, a slight indication of a band in green from 84 to 93. Before the addition of the barium and nitric acid the HCl solution measured—

1. 51 to 58 = 7; Int. 1; R. = β.
2. 61 „ 77 = 16; „ 3; „ = α.

Consequently the bands are the same in situation, but changed a little in relative intensity, the difference being greatest in the solution from which H_2SO_4 was removed. *Consequently this body is not a sulphate, although its spectrum is almost identical with that of cruentine sulphate.*

Residue.

The residue on filter from first HCl decoction was again treated with HCl, and found soluble in alcohol. It had the same bands as the above solution, but being more concentrated the whole spectrum was more obscure. *A special obscuration in red* reached from 34 to 47. Addition of NH_3 produced the four-banded alkaline cruentine.

1. 44 to 48 = 4; Int. 1.
2. 52 „ 68 = 16; „ 3. Greatest or axis intensity of this band at 64.
3. 71 „ 85 = 14; „ 4.
4. 88 „ 105 = 17; „ 5.

There ensued a precipitate in the solution. After filtration the spectrum was lighter, but the absorption also less intense. It is therefore possible that both the soluble and insoluble part were four-banded cruentine.

Action of soda, &c., upon cruentine.

Action of Soda, Hydrochloric Acid, and Ammonia upon Cruentine.— The crude or total cruentine was as in the foregoing experiment boiled for weeks with soda, afterwards dissolved in hydrochloric acid and boiled; the insoluble part was filtered from the solution, and the latter mixed with alcohol. This showed most distinctly the band in red which had been surmised to exist in the previous observation.

1. 35 to 46 = 11; Int. 2; R. α.

Shading commences at 51. More diluted there appeared—

2. 60 to 84 = 24; Int. 2.
3. 90 „ 107 = 17; „ 1. (Very difficult to determine.) End at 125.

This, therefore, is the second hydrochloric acid product described

on p. 232 of Rep. of 1868, but it differs in the intensity of its absorption.

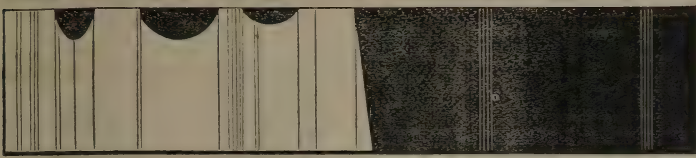

Diagram of the Hydrochlorate of Cruentine described in the foregoing.

Treated with excess of ammonia this body assumed the spectrum of the alkaline four-band cruentine represented on p. 229 of Rep. 1868, first diagram.

1. 44 to 49 = 5 ; Int. 1.
2. 53 „ 69 = 16 ; „ 2.
3. 73 „ 85 = 12 ; „ 3.
4. 89 „ 105 = 16 ; „ 3.

Cruentine and nitric acid.

The part which had become precipitated in the HCl solution after resolution in soda carbonate, also showed the four-band spectrum.

Cruentine and Nitric Acid.—Solid cruentine as it came from the sulphuric acid process, containing yet $H_2\,SO_4$, was dissolved in hot nitric acid, and heated until no more red vapours were evolved; it formed a yellow thick solution of an aromatic smell. Addition of water precipitated a yellowish green matter, which became darker by exposure, and shrunk much during drying. The dried matter was only partially soluble in alcohol of 80 °/$_0$; more dissolved on boiling, and was deposited on cooling. The alcoholic solution after neutralization with ammonia gave a precipitate with silver nitrate, which became darker on standing.

Precipitate by Ag.

The precipitate by water was soluble in ammonia, and this solution gave precipitates with $Ca\,Cl_2$ and $Ba\,Cl_2$, which were yellow, the solution remaining strongly yellow. The acid water from which the flakes had been precipitated was evaporated to dryness, and again mixed with water. Then brown resinous drops were deposited which did not solidify on standing for some days; consequently several bodies are formed under the influence of nitric acid. (1.) A yellow body soluble in alcohol, nitrocruentine. (2.) (3.) Two yellow bodies insoluble in alcohol on boiling. The mixture was treated with ammonia, which dissolved one portion, namely, the body (2), or nitrocruentic acid, and left (3) nitrocruorine. This on boiling with water, and repeated addition of ammonia, swelled, but did not dissolve; on attempted filtration it speedily clogged the filter. (4.) Brown resinous drops. (5.) The watery acid solution containing probably oxalic acid and a yellow product. Neutralised with baryta water and barium carbonate it yielded a yellow neutral filtrate, which on evaporation became darker every moment, and ended as a completely decomposed brown, hard, blistery mass. It had been treated exclusively on the steam-bath, where a higher temperature than 90° to 95° could not be attained.

Brown semi-fluid resin.

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J.—*A peculiar Reaction of Cod-liver Oil, and a similar Reaction of Fatty Matter from Fibrine of Blood.*

a.) When cod-liver oil is treated with concentrated sulphuric acid it immediately yields a purple reaction. The mixture cannot well be diluted with more oil, as in that case it becomes turbid, but on dilution with concentrated sulphuric acid a beautiful purple liquid is obtained. This when examined before the spectroscope with Drummond's light, allows red, yellow, and green to pass up to 74. On great dilution with acid the absorption recedes towards violet. When blue begins to appear, green is perfectly clear. The acid solution fluoresces green, and on further dilution becomes yellowish brown.

The addition of a trace of sugar to the cod oil greatly intensifies the reaction, and causes it to remain red on dilution with acid, and not to become yellow so quickly as otherwise. This mixture yields the following spectrum :—

Band 73 to 100, when dilute. Intens. 1 ; or 73 to 110, when more concentrated.

At the end there is a lavender coloured band up to 145, where spectrum ends.

Diagram of Spectrum of Reaction of Cod-liver Oil with Sulphuric Acid and Sugar.

b.) A large quantity of fibrine which had been most carefully washed was dissolved in dilute sulphuric acid. On standing a scum collected on the top, which was washed by repeated decantation, ultimately on the filter. Gradually after the last filtrates, when the paper had become dry and the temperature of the air become high, some *fluid oil* percolated which had the following properties :—It was colourless. With sulphuric acid it immediately gave the red test for cerebric acid. With sulphuric acid and sugar it gave the purple test, and on standing two days gelatinised in a curious manner and became black. The *alcohol extract* from this was red, and showed the following spectrum :—

Red, yellow, and green to 75, then dark to end.

On cautious further dilution a feeble band becomes isolated—

80 to 113 = 33. Intens. 1.

After which there is a beautiful violet band to the end at 146.

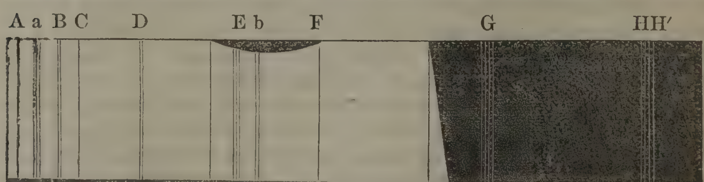

Diagram of Spectrum of Reaction of Fibrine Oil with Sulphuric Acid and Sugar, extracted by Alcohol.

More diluted absorption remains, 87 to 113 = 32. Violet gets more blue and extends to 166, when absorption disappears.

When describing the ingredients of the corpora lutea of cows, I gave a peculiar reaction which their juice, obtained by heat, yields with sulphuric acid and sugar. The mixture became purple, and its spectrum showed a band in green.

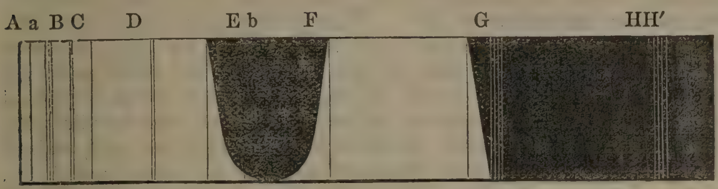

Diagram of Purple Test of Juice of Corpora Lutea.

76 to 113 = 37. Intens. 10. Cut off at 155.

Cod-liver oil gave spectrum—

73 to 110 = 37. Intens. 1. End 145.

Fibrine oil gave spectrum—

80 to 113 = 33. Intens. 1. End at 146.

These spectra are so very similar to each other that they may be due to one and the same body, which we may assume to be an ingredient of all three animal liquids employed. The greatest difference is exhibited by the spectrum of the juice of the corpora lutea, which has an intensity of 10, while the other bodies are much less intense, remaining about 1. This may be due to the circumstance that the juice contains much more of the substance yielding the reaction than the two oils.

The spectra which cod oil and fibrine oil yield when treated with sulphuric acid only, without any sugar, give the same continuous absorption in blue and violet, and are therefore identical.

All solutions show a slightly green fluorescence, those with acid only most conspicuously, those with sugar least. From the foregoing we may draw the following conclusions :—

1. Cod-liver oil, fibrine oil, and the juice of corpora lutea contain each a peculiar substance, the particular chemical properties of which are similar in all three mixtures.

2. The colour test of these substances is apparently identical with the test which cerebric acid, lecithine, and biliary acids yield with the same reagents. Spectrum analysis shows, however, that the test of cerebric acid and lecithine with sulphuric acid alone exhibit absorption bands, while the three matters under examination do not show absorption bands under the same circumstances.

3. The reaction of biliary acids with sulphuric acid and sugar (Pettenkofer's test) yields a spectrum with three bands, one band overlying the D line. (See p. 256 of last Report.) The same reaction with cerebric acid yields a spectrum with a band in green midway between D and E ; but with the substance in the three bodies the same reaction gives a spectrum with a band which reaches from midway between D and E to nearly F, and which is therefore not only moved more towards the violet end but also much broader.

4. I think it probable that the substance in cod-liver oil is derived from the liver-cells, that in fibrine from white blood corpuscles entangled in the fibrine, and that in the juice of corpora lutea from the peculiar cells of those bodies.

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K.—*Chronic Yellow Atrophy of the Liver, or Malignant Jaundice.*

Notes of case. Characters of urine.

The subject of this disease was a man about 45 years of age, who had gradually become jaundiced. There was no history of gallstones, and the colour of the fæces indicated a diminution only, not a complete arrest, of the excretion of bile. The patient had fever, and was dropsical, the ascites being considerable. The liver on percussion was found much reduced; the fluid in the abdomen, however, made the exact determination of its limits difficult. The first urine examined amounted to 200 CC, and was very bilious, yielding the test for bile-acids with sulphuric acid and sugar, for cholophæine with nitric acid, and, as was supposed, for tyroine with nitrate of mercury containing subnitrite. It contained a little albumen. It was filtered and precipitated with lead acetate, heated, filtered, and washed. The filtrate was evaporated to small bulk and treated with alcohol. A precipitate ensued. This was filtered off and washed with alcohol, and then extracted with concentrated ammonia. It was then boiled with water, which extracted much matter and left a little xanthine undissolved. The solutions gave a white precipitate with mercury nitrate, and no red colour with nitrite, thus showing that tyroine was *not* present.

Xanthine and hypoxanthine.

The solution in water was evaporated and left a colourless amorphous residue. This dissolved easily in nitric acid without effervescence or red vapours, and on drying at a gentle heat a purple residue remained, which became bluish-purple with caustic potash. Concentrated hydrochloric acid dissolved a portion, and crystals formed on evaporation, which did not polarize, consequently were not uric acid. On boiling in a little water these crystals left again amorphous matter which became insoluble. We have therefore probably both *xanthine* and *hypoxanthine* in this water extract. The first residue, insoluble in water, was certainly xanthine, and the second matter may have been hypoxanthine, although the circumstance that it gradually became insoluble also points towards xanthine; for it is a well-established property of xanthine to become more and more insoluble in water the more frequently it is dissolved in or treated with it.

Volatile aromatic oil.

The reaction which simulated the presence of tyroine was probably due to the volatile aromatic oil present in every urine, and which I have first described in the Hastings Prize Essay; but this must certainly have been present in great excess before it could give so intense a reaction. Thus far, therefore, there were only biliary matters as abnormal ingredients; the other isolated bodies were normal.

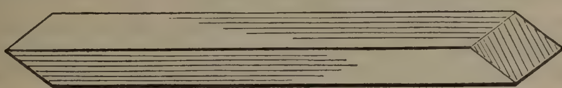
Peculiar crystals.

The urine of the second day of observation was 630 CC, strongly yellow; after filtration in bulk greenish brown. The filter remained yellowish red, as if stained by cholophæine. It was precipitated with lead acetate, the filtrate treated hot with hydrothion and filtered. On standing 36 hours it deposited a mass of peculiar filmy crystalline needles. They were isolated, the mother liquor further evaporated, and allowed to stand.

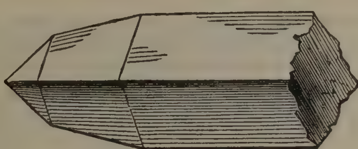
Para-uric acid.

In the same manner the urine of ten consecutive days was treated, and the crystals obtained were united. On examination they were found to be a particular new form of uric acid, which may be called *para-uric acid.* This substance is similar to xanthine by its reaction with nitric acid, and by the behaviour of its nitrate of silver compound when dissolved in nitric acid. It is similar to hypoxanthine or sarkine in its crystallised form, solubility in water, and deposition from boiling water, and in the reaction with nitric acid. But it differs from hypoxanthine in this, that its silver nitrate compound is easily soluble in nitric acid, and not easily deposited on cooling, while hypoxanthine silver

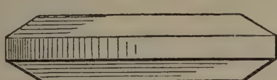
nitrate is completely deposited. It differs from both xanthine and hypoxanthine in this, that its watery hot solution, when precipitated by silver nitrate, yields a compound, which, when freed from all excess of silver, dissolves easily in nitric acid with effervescence, and deposits nothing on cooling. After much evaporation, however, and cooling, it deposits nitrate of silver, thus showing that in the nitric acid solution the nitrate of silver and nitrate of para-uric acid are not combined. The mixture of nitrate of silver crystals and para-uric acid nitrate, after re-solution in water, yields a copious precipitate with ammonia, which, bulky at first, contracts in excess. This is similar to both xanthine and hypoxanthine. It differs from both in this, that it dissolves in dilute nitric acid under evolution of carbonic acid. The solution on evaporation leaves a purple residue. Para-uric acid differs from uric acid by its solubility in water, and greater solubility in hot water, forming a crystallised deposit; by its peculiar shape of crystals, which are needles of long rhombic prisms with complicated ends, being a combination of two rhombic octahedra; and by its saturated solution in cold water on addition



of hydrochloric acid immediately depositing fine lustrous crystals, which under the microscope have this shape. Para-uric acid is, however,



similar to ordinary uric acid by its insolubility in cold, slight solubility in boiling concentrated hydrochloric acid; by its solubility under evolution



of carbonic acid (and nitrogen?) in dilute nitric acid, and by the purple-coloured residue of this solution on evaporation to dryness.

Biliary colouring matter.

The lead precipitate after washing was suspended in alcohol and decomposed by hydrothion. The filtrate was allowed to evaporate spontaneously. A greenish yellow residue remained, which was entirely soluble in water, and against expectation did not give the nitric acid test of cholophæine. This substance or its derivate had therefore been lost or changed during the chemical process for its isolation.

Results.

Results.—The nitrate of mercury test applied to urine directly may indicate tyroine when none is present. The reaction is due to the essential oil. The urine in chronic malignant jaundice contains biliary matters, and an anomalous acid of the uric acid group, to which the name of para-uric acid has been given. It does not contain tyroine or leucine, bodies which are often present in the acute form of the disease.

L.—*On a peculiar Reaction of Lecithine from Yelks of Eggs with Sulphuric Acid, and on primary and secondary Absorption Spectra.*

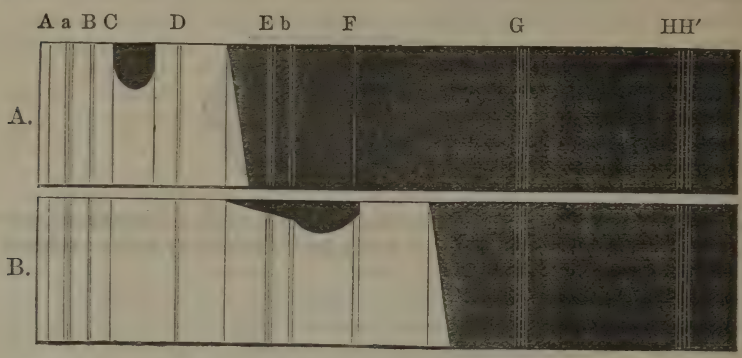
The extract of yelk of egg by chloroform or ether, after evaporation of the solvent, is a semifluid yellow mass, in which on standing fine crystals of lecithine are deposited. When it is shaken with concentrated acetic acid much luteine dissolves, and oily drops remain suspended. But none of the substances can at present be perfectly isolated. Treated with concentrated sulphuric acid it gives a blue reaction, due to luteine, which passes into green and then into red; this becomes darker every moment and shows spectrum:

Band in red and orange 40 to 53 = 13; intens. 3; R. α. In very dark solution the band reads 42 to 56. Yellow from 59 appears green and shaded to 71, where spectrum is cut off. The solution has a powerful green fluorescence.

On dilution blue appears at 114, reaching to 139, and in green a band remains, feeble from 74, becoming intensity 3 at 95, and ending at 114.

1. 40 to 53 = 13; Intens. 3; R. α.
2. 74 „ 114 = 40; „ 2; „ β.

When 2 can be seen and measured, 1 has quite disappeared. The first spectrum is therefore the primary (A.), and the last one the secondary (B.) spectrum.



Diagrams of Primary and Secondary Spectrum of Lecithine from Yelk of Eggs with Sulphuric Acid.

The spectrum A. has already been described and figured on p. 185 of the 10th Report of the Medical Officer, but is there erroneously named as that of vitelline. It is, however, correctly alluded to under its proper name in the comparison with the biliary tests on p. 256.

M.—*On Leucine, its Purification, Compounds with Copper, and Extraction from Morbid Fluids and Tissues.*

1. *A new Mode of purifying Leucine.*

The study of the chemical and dynamical relations of this substance is of great importance, as it is not only a normal ingredient of some parts of the animal body, but a constant and copious product of the natural and artificial decomposition of albuminous substances. In pathological conditions of the human body it appears in various organs, particularly the liver, and then it is also not rarely excreted by the urine. (Malignant jaundice.) The circumstance that it is a homologue of glycocoll, (the normal copula of cholic acid in glycocholic acid of the bile, and of benzoic acid in the hippuric acid of the urine,) invests it with great theoretical interest. Some time ago I undertook an inquiry into some of its transformations, an account of which has been published in the Journal of the Chemical Society. The production of an acid free from nitrogen, and more oxydised than caproic acid, and of many of its salts, was the principal result of that inquiry. This leucic acid ($\text{C}_6H_{12}\text{O}_3$) was shown to be homologous to lactic acid (C_3H_6O_3), as the homology of leucine to glycocoll led the inquirer to suppose. But the great difficulty in procuring leucine in quantity prevented an extension of this research over a greater area. This has now been overcome to a great extent by the following new proceeding.

The raw leucine, as obtained by the inspissation and cooling of the mother liquors of tyroine, freed from mother liquor by pressure and dried, is treated with concentrated nitric acid while being triturated in a mortar and gently heated, until a slight reaction is perceived. The nitric acid solution is then diluted with water, and a solution of nitrate of oxyde of mercury is added as long as a precipitate is thereby produced. This is removed by filtration. The filtrate is allowed to stand for some days, during which time a reduction of mercury takes place. The excess of mercury is then removed by sulphuretted hydrogen. The filtrate is neutralized by ammonia and evaporated until a pellicle forms. The leucine which is separated on cooling is collected on a filter, washed with concentrated alcohol until the filtrate is colourless, and dried. It is then dissolved in boiling water, treated with pure animal charcoal, and filtered; the filtrate is evaporated in a covered china capsule (a Berlin porcelain capsule with wooden handle and spout and china cover is best for that purpose) until it is saturated on boiling, (forms a pellicle imme- Process.

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diately on the cover being removed,) and then poured into three or four times its volume of very strong alcohol. White leucine crystallises almost immediately, and on standing. After 24 hours the leucine is collected on the filter, washed with alcohol, and dried on blotting paper. If it is not perfectly white and brilliant and free from smell, it must be dissolved once more in boiling water filtered, and after concentration poured into alcohol.

Thus purified leucine is a matter of a very light specific gravity, owing to the excessive thinness of the scales; it is perfectly white and of great splendour; it can be sublimated in white flakes without leaving any residue; in short all possible chemical tests show it to be perfectly pure.

In this manner I have purified leucine obtained from horn; from human and other hair; from albumen; from fibrine; from the human liver in several diseases—paralysis and Bright's disease, pyæmia, and tetanus; from the human spleen and kidneys in pyæmia and tetanus; and from liver substance which was allowed to putrefy in a vessel from which air was excluded.

2. *On the Compounds of Leucine and Copper.*

Preliminary remarks. Leucine and cupric hydroxyde. Leucine and cupric acetate.

a. Preliminary Remarks.—It is desirable to possess means by which leucine can be completely removed or precipitated from solutions in such a manner as not to interfere with their further analysis. When we consider the compounds of leucine hitherto known, it is clear that none of them offers the necessary conditions for the accomplishment of this object. The researches of Goessmann (Ann. Chem. 91, 133) had shown that copper oxyde readily combined with leucine, and formed a compound of slight solubility. But as for complete precipitation an excess of the oxyde would have to be used, it was to be apprehended that the copper compound obtained must contain an admixture of basic salt, or of uncombined oxyde, and could therefore not be analysed directly, but had to be re-formed into a compound of definite proportions. It had been stated by Strecker that leucine displaced the acid of copper acetate, and formed an insoluble compound with the metal. To the application of this reaction there was the objection that it imported acetic acid into fluids which may contain this or nearly allied acids as essential ingredients. I therefore endeavoured to find a process which should combine all leucine contained in any fluid at once with an invariable quantity of copper, without leaving any excess of copper or any other acid in the fluid, and should subsequently yield the leucine copper compound in an insoluble form ready for analysis. This was effected by the following proceeding.

Mode of obtaining new compound.

b. Mode of obtaining new Copper Compound of Leucine, or Dicupric Trileucine.—On adding to a solution of leucine cautiously a concentrated solution of copper sulphate, until caustic potash produces a precipitate in a filtered sample of the cold solution, a fluid of a deep blue colour is obtained. This is treated with barium carbonate and boiled until an excess of this earth does not any longer cause effervescence, and a filtered sample of the solution remains clear with barium chloride and nitric acid. The filtrate, a fluid of a beautiful deep blue colour, is free from sulphuric acid, contains a quantity of copper in solution which stands in a certain proportion to the amount of leucine present, and on evaporation on the water bath at a gentle heat on standing and cooling deposits a light blue mass of crystalline granules. The new compound after being washed with water for some time is then washed with alcohol until the washings are colourless, and dried over sulphuric acid. It is a pale blue granular mass and becomes sky-blue

Properties of new product.

by being powdered. It leaves copper oxyde on combustion. When heated in a glass tube open at both ends it emits white and alkaline fumes of the strong and characteristic odour of amylamine. When the compound is boiled with water little only dissolves. Its mother liquor evaporated to dryness, and again treated with water to the extent of the original solution, deposits a further mass of scales and crusts, which are also nearly insoluble in even boiling water. Thus almost the entire amount of leucine contained in the fluid is obtained in the form of this insoluble copper-compound.

Analyses.

Analyses.—Dried in the steam-closet until the weight was constant—

a. 0·345 grm. gradually ignited gave 0·1044 grm. of copper oxyde, equal to 0·0833 of Cu, or 24·14 °/₀ of copper in the compound.

b. 0·2946 ignited gave 0·091 CuO, equal to 0·0726 Cu, or 24·64 °/₀.

c. 0·5248, burned with soda-lime, gave out ammonia, which combined with 0·3036 grm. of platinum, &c., and therefore contained 0·04357 grm. of nitrogen, or 8·30 °/₀.

Second mode of obtaining.

Second Mode of obtaining.—The same compound was obtained by boiling a solution of leucine with bright copper wire newly reduced in hydrogen, for some days on the sand bath. The salt was deposited from the solution filtered boiling; the solution retained little copper, and contained excess of leucine. The compound was therefore soluble in a solution of leucine, but much less soluble in water. It was insoluble in strong acetic acid. The analysis gave the following result:—

d. 0·0785 grm. left 0·0240 CuO, equal to 24·42 °/₀ Cu.

Third mode of obtaining.

Third Mode of obtaining.—The same compound was obtained by adding copper oxyde to a solution of leucine hydrochlorate. This experiment will be more fully described lower down.

e. 0·0912 grm. left 0·0270 grm. CuO, equal to 23·64 °/₀ Cu.

Fourth mode of obtaining.

Fourth Mode of obtaining.—By evaporation of the mother liquor of monocupric dileucine obtained by copper acetate (see lower down).

f. 0·6339 left 0·1840 grm. CuO, equal to 23·17 °/₀ of Cu.

The compound obtained by the four processes described consists of three atoms of leucine, in which four atoms of hydrogen are substituted by two atoms of copper.

Formula.

Its formula is $C_{18}\,H_{35}\,Cu_2\,N_3\,O_6$.

Synopsis of analyses.

Atoms.	At. Weights.	in 100.	Found. a.	b.	c.	d.	Mean.
C_{18}	216	,,	,,	,,	,,	,,	,,
H_{35}	35	,,	,,	,,	,,	,,	,,
Cu_2	126·8	24·58	24·14	24·64		24·42	24·47
N^3	42	8·14	,,	,,	8·30		
O_6	96						
	515·8						

This compound, therefore, stands midways between the neutral salt $C_{12}\,H_{24}\,Cu\,N_2\,O_4$, requiring 19·6 °/₀ of Cu and a hypothetical cupric monoleucine $C_6\,H_{11}\,Cu\,NO_2$, demanding in theory 32·95 °/₀ of Cu.

Deep blue colour of leucine and copper sulphate mixture.

The mixture of leucine and copper sulphate assumes a deep blue colour immediately on the addition of the sulphate. The colour is darker than that of the saturated copper sulphate solution, even when only a few drops of it are added to a saturated leucine solution, which if

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they were added to the same bulk of water would be scarcely sufficient to impart to it any blue tint whatever. The amido-acid in the sulphate therefore increases the colour of the copper salt analogous to ammonia. The removal of the sulphuric acid and excess of copper oxyde by barium carbonate leaves the solution still darker.

Spectral analysis of blue solution.

Both solutions examined in the spectroscope absorb one half of the red part of the spectrum. The yellow and orange become green, the green dark, the blue lighter, but no detached absorption bands are discernible with lamp-light. The salts therefore behave like inorganic copper-salts.

(*f.*) *Application of the Method to the Separation of Leucine from Extract of a Liver suspected to contain Leucine.*

Separation of leucine from liver.

The liver was extracted with boiling water, the extract treated with lead acetate, the filtrate freed from lead by hydrothion, and evaporated to crystallisation. The mother liquor was separated, the residue treated with spirit, the spirit extract dried, dissolved in water, and saturated with copper oxyde by the addition of cupric sulphate and boiling with barium carbonate. A deep blue solution resulted, in which on evaporation some reduction of copper took place. The insoluble greenish blue leucine-copper was separated and washed, dried at 110°, and analysed.

(*a.*) 1·4703 grm. burned in platinum crucible left 0·4284 grm. copper oxyde, or 23·26 °/$_{o}$ of Ꞓu.

(*b.*) 0·7171 grm. burned in platinum crucible left 0·2077 ꞒuꝊ, or 23·12 °/$_{o}$ Ꞓu.

(*c.*) 0·6614 grm. burned in china capsule gave 0·1899 ꞒuꝊ, or 22·92 °/$_{o}$ of Ꞓu.

The mean of these analyses is 23·10 °/$_{o}$ of Ꞓu, and differs from the mean found in the pure preparation by 1·2 °/$_{o}$, from theory by 1·4 °/$_{o}$. This difference is, however, unimportant, as the data still support the theory, and because the difference is fully accounted for by the slight deoxydation and consequent separation in the form of pulverulent suboxyde of copper which a minute portion of the dissolved copper oxyde experienced. In a similar case it would be necessary to allow the oxydisable matter to saturate itself with oxygen from copper, and then to saturate the leucine, which has been deprived of a portion of its copper, a second time with copper oxyde. This may be done in all cases where a very pure preparation is desired at once, and a considerable loss of leucine by the earlier precipitation of the compound is of secondary importance. It is best to employ copper oxyde which has been kept under water and become finely pulverulent and reddish black. In some cases a few drops of a solution of copper acetate may be sufficient to restore the deoxydised copper.

To impure extracts of organs which contain much undefined oxydisable matter the method is as yet not well applicable. The product obtained is green and very impure. Nevertheless, from some extracts of cholera organs which had been analysed for urea some scales of copper leucine could be extracted which admitted of perfect identification.

(*g.*) *Monocupric Dileucine, obtained by means of Copper Acetate.*

Leucine copper made by adding copper acetate to a hot solution of leucine.

On adding to a concentrated hot solution of leucine kept on the steam-bath a quantity of saturated solution of copper acetate, the fluid becomes for a moment deep blue, and then immediately deposits a light granular precipitate. This increases by stirring, and the fluid is decolorised. The continued addition of copper acetate brings the precipitate to a

maximum, and the fluid then remains of a more saturated blue. Thin scales form on the surface. They are decanted with the blue fluid from the precipitate, and the latter is placed on a filter. The washings are only faintly blue, lastly almost colourless. To boiling water the precipitate yields a portion of matter (monocupric trileucine and dicupric trileucine), which will be considered lower down. Dried at 110° until constant, it is a beautiful sky-blue powder with no particular lustre.

Analyses :—

(*a.*) 0·6353 grm. burned in a china crucible left 0·1490 grm. CuO, equal to 18·72 °/$_{o}$ Cu.

(*b.*) 0·6511 grm. left 0·1536 grm. CuO, equal to 18·85 °/$_{o}$ Cu.

(*c.*) 0·3492 grm. burned with lead chromate gave 0·5604 CO_2 and 0·2601 H_2O, equal to 43·77 °/$_{o}$ C and 8·27 °/$_{o}$ H.

From a comparison of the above analyses with the theory of anhydrous monocupric dileucine (atom. weight, 323·4),

Atoms.	Atomic weight.	In 100.	Found. a.	b.	c.	Mean.
C_{12}	144	44·52	„	„	43·77	„
H_{24}	24	7·42	„	„	8·27	„
Cu	63·4	19·60	18·27	18·83	„	18·55

it will be seen that the carbon and hydrogen analyses support the theory of the anhydrous compound, containing in theory 2·4 °/$_{o}$ C more than the hydrated, better than that of the hydrated, stated below, while the copper meets the requirements of the hydrated salt. But as four different preparations hereafter to be described support the probability of this salt being always hydrated, the above salt may be assumed also to contain one atom of water.

The solution from which the foregoing compound had been deposited, on evaporation formed scales on its surface which resembled those of dicupric trileucine as obtained by the barium process. The fluid when allowed to cool became turbid. The washed precipitate after extraction with boiling water was analysed. 0·6339 grm. left 0·1840 grm. CuO, equal to 23·17 °/$_{o}$ Cu, or exactly the mean found in the compound from the liver extract (23·10 °/$_{o}$).

(*h.*) *Hydrated Monocupric Dileucine, obtained by saturating a boiling Solution of Leucine with Cupric Hydroxyde.*

Goessmann (Ann. Chem. 91, 133) obtained a compound of leucine and copper, by saturating a solution of the former, while boiling, with hydrated copper oxyde, and cautiously concentrating the solution on the water bath. On cooling a granular crystalline dark blue compound resembling oxyde of copper ammonia was deposited. When the solution was concentrated quickly the compound was deposited in scales on the surface and at the bottom of the fluid. The crystalline deposit and the scales were analysed together, and yielded the following numbers. The matter was dried at 100° C. The copper was found so low as to justify the assumption of the compound having been a hydrate. But the hydrogen was one per cent. below the theoretical quantity, and as will be seen from a comparison with the theory of the anhydrous salt, was actually 0·7 °/$_{o}$ below the theory of this latter. On the other hand, the carbon should have been rather higher, if the compound had been partially dehydrated. I once obtained a compound with a similar

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amount of copper (18·62 °/$_0$), by treating a large quantity of leucine dissolved in weak spirit with some copper oxyde and metallic copper.

Theory of hydrated monocupric dileucine. Atomic weight = 341·4.

		In 100.	Goessmann.	Th.	Mean of compd. by Ꞓu acetate.
$Ꞓ_{12}$	144	42·17	41·33	"	43·77
H_{26}	26	7·61	6·69	"	8·27
Ꞓu	63·4	18·56	18·20	18·62	18·55

(*i.*) *Dicupric Trileucine and Monocupric Dileucine obtained from Leucine Hydrochlorate by repeated addition of Copper Oxyde.*

The solution which remained after the mercury of some mercuric leucine had been precipitated by H_2 Ꞩ out of its HCl solution, was evaporated to dryness to chase away all excess of HCl, then redissolved, and while hot treated with cupric hydroxyde. An insoluble blue compound (No. 1) immediately formed. Analysis, 0·0912 grm. burned left 0·0270 grm. of copper oxyde, equal to 23·64 °/$_0$ Ꞓu.

The solution was evaporated to dryness on the water bath, and yielded a blue compound (No. 2) covered by a thin layer of green. The latter, copper chloride, easily dissolved in water with a blue colour, while the blue compound remained undissolved. Dried at 110°. Analysis: 0·1986 grm. burned left 0 0452 ꞒuꝊ, equal to 18·17 °/$_0$ Ꞓu.

The mother liquor or washings of the foregoing compound were heated and treated a second time with copper oxyde; this at first dissolved, but the clear solution began to get turbid and a new quantity of precipitate (No. 3) fell down.

Analysis: 0·1852 grm. left 0·0420 ꞒuꝊ, or 18·11 °/$_0$ Ꞓu.

The filtrate from this was now saturated with copper oxyde, filtered from the excess, and the blue filtrate evaporated on the water bath. It deposited sky-blue granules (No. 4) besides green copper chloride. The latter was removed by washing with water.

Analysis: 0·2318 grm. left 0·0532 ꞒuꝊ, equal to 18·33 °/$_0$ Ꞓu.

The filtrates were again evaporated, and deposited a salt (No. 5) which was analysed.

Analysis: 0·1067 grm. left 0·0248 grm. ꞒuꝊ, equal to 18·56 °/$_0$ Ꞓu.

All the precipitates were washed until the washings were free from chlorine. The precipitates were then specially analysed for chlorine, but found not to contain any. The copper oxyde thus separated the leucine from the hydrochloric acid, forming at first and only once dicupric trileucine, afterwards under varying conditions four times monocupric dileucine. In each preparation copper chloride was found and observed to diminish until the last. It is therefore evident that leucine when evaporated with copper chloride in proper proportions drives out the hydrochloric acid almost as easily as the acetic acid from the acetates of copper and mercury.

Fluorescence of washings of the above solutions.

The latest washings from the above compounds were clear and colourless in transmitted light, even in thick layers. But they fluoresced copper blue in diffuse light, and strongly whitish blue in sunlight. Sunlight thrown into the fluid with a lens produced an intense white blue pencil of fluorescence.

Synopsis of the quantity °/$_0$ of Ꞓu found in the compounds :—

No. 1.	No. 2.	No. 3.	No. 4.	No. 5.
23·64.	18·17.	18·11.	18·33.	18·56.

The last preparation thus contained exactly the amount of copper required by the hydrated monocupric dileucine.

(*k.*) *Monocupric Trileucine.*—$C_{18}\ H_{37}\ Cu\ N_3\ O_6$.—When the first granular precipitate, which is produced by copper acetate in a hot solution of leucine, is after complete washing with cold water boiled in a large quantity of water, a small quantity of two compounds dissolves, of which the one is deposited from the filtrate on cooling in light crystalline clouds; the other remains in solution. Under the microscope the deposit appears as rosettes of scales, belonging to the rhombic system apparently. But the angles of the scales are very uncertain. Washed and dried they form an exceedingly light mass, of the peculiar lustre of leucine itself, having also its fatty feel, but in addition a splendid soft light sky-blue colour. The masses are so highly electric that they adhere to paper or a knife like needles to a magnet.

Analysis: 0·1515 grm. on combustion left 0·0273 CuO, equal to 14·38 °/₀ Cu.

Theory of monocupric trileucine:—

		Calc. in 100.	Found.
C_{18}	216	„	„
H_{37}	37	„	„
Cu	63·4	13·95	14·38
N_3	42		
O_6	96		
	454·4		

The mother liquor from which the foregoing compound had been deposited measured 358 C.C., had a faint blue colour, and on evaporation to dryness left a quantity of salt, which dried at 110° C. weighed 0·1012 grm. On combustion it left 0·0283 grm. CuO, equal to 22·29 °/₀ Cu. and was therefore dicupric trileucine.

A precipitate was therefore formed by the copper acetate in the leucine solution, which consisted mainly of *monocupric dileucine.* From this boiling water extracted *monocupric trileucine*, which was deposited on cooling of the water, and *dicupric trileucine*, which was left pure after the evaporation of the fluid. It is possible that the latter two bodies were originally formed and mixed with the first compound. It may, however, also be supposed that monocupric dileucine is decomposable by boiling at a certain period after its formation, and in small quantity, and that three atoms of it break up according to the following formula:—

(L = leucine.)

$$\underbrace{\left\{\begin{matrix} L\ L \\ Cu \end{matrix}\right\} \left\{\begin{matrix} L\ L \\ Cu \end{matrix}\right\} \left\{\begin{matrix} L\ L \\ Cu \end{matrix}\right\}} = \left\{\begin{matrix} L\ L\ L \\ Cu \end{matrix}\right\} + \left\{\begin{matrix} L\ L\ L \\ CuCu \end{matrix}\right\}$$

3 atoms monocupric dileucine.	1 atom monocupric trileucine.	1 atom dicupric trileucine.
$Cu = 18{\cdot}56$ °/₀.	$Cu = 13{\cdot}95$ °/₀	$Cu = 24{\cdot}58$ °/₀

3. *On a new Compound of Leucine and Mercury, Pentamercuric Hexaleucine.*

The neutral compound $C_{12}\ H_{24}\ Hg\ N_2\ O_4$ is made by dissolving such a quantity of freshly precipitated mercury oxyde in a hot solution

of leucine, that on cooling a turbidity ensues in the fluid. This solution on evaporation deposits the above salt. But when it was attempted to obtain this compound by acetate, as in the analogous case of the copper-compound, a new salt was obtained.

To a hot solution of leucine a concentrated neutral solution of mercury acetate was given, and the mixture heated gently. A white granular precipitate ensued, which was separated by the filter from the hot fluid. (First precipitate.) The mother liquor was evaporated by steam to a concentrated state, when much acetic acid escaped, but no deposit ensued. The addition of water produced an immediate white, slightly pink precipitate. The acid compound was evidently decomposed by water. The precipitate was filtered off and washed. (Second precipitate.) The washing water made the filtrates again turbid.

First Precipitate, or Pentamercuric Hexaleucine.—The precipitate was washed, then suspended in hot water, boiled, filtered, and again washed. The filtrate contained a mercurial leucine compound. The precipitate was a slightly yellowish heavy powder. It was dried at 110° C.

Analysis: 4·2527 grm. were dissolved in dilute hydrochloric acid. A small quantity of yellowish impurity was removed by filtration, and the filter washed to exhaustion. The application of hydrothion yielded 2·8167 grm. of mercury sulphide, equal to 57·09 °/₀ $\cancel{H}g$. This leads to $\cancel{C}_{36} H_{69} \cancel{H}g_5 N_6 \cancel{O}_{12}$, as the formula of this compound, being *pentamercuric hexaleucine.*

$$\overbrace{\underbrace{\cancel{H}g}_{L\ L} \quad \underset{L}{\cancel{H}g} \quad \underset{L}{\cancel{H}g} \quad \underset{L}{\cancel{H}g} \quad \underset{L}{\cancel{H}g}}$$

Atoms.	At. Wt.	in 100.	Found.
36 $\cancel{C}$	432	,,	,,
69 H	69	,,	,,
5 $\cancel{H}g$	1000	57·94	57·09
6 N	84		
12 $\cancel{O}$	192		
	1777		

The *second precipitate*, after treatment like the first, did not appear to differ in composition or properties.

4. *Leucine-lead*, $\cancel{C}_{12} H_{12} \cancel{P}b N_2 \cancel{O}_4$.—The neutral compound was obtained by Strecker by adding to a boiling mixture of leucine and lead acetate cautiously a little ammonia. When I took a solution of leucine, saturated boiling, added lead acetate and a little ammonia, only a trifling precipitate ensued while the fluid was boiling; but on cooling, the whole fluid filled with this very insoluble compound of lead and leucine.

N.—*On a Series of New Yellow Substances contained in Animals and Plants.**

A. *Animal Series.*

B. *Vegetable Series.*

Introduction.

Introduction

The following researches arose in an endeavour to define chemically and spectrologically the substance which passes in works on morbid anatomy and chemistry under the name of "hematoidine." In this endeavour the author was completely disappointed, as during the examination of more than 1,200 different specimens of healthy or morbid tissues "hematoidine" was never once met with. The author does not, therefore, assume that hematoidine, as originally described by Virchow, does not exist. He believes, however, that several matters have erroneously been termed hematoidine, which were either cholophæine or luteine. Neither of these last two bodies have any apparent relation or similarity to hematoidine, or to any of the numerous derivates of the colouring matter of the blood which have been described in the Tenth Report of the Medical Officer. Luteine in particular offered properties so peculiar, that it was specially investigated, and there was found such a wide distribution of it, or of bodies very closely resembling it, that the subject was followed out as far as time and opportunity permitted. The whole of the new substances met with were, according to their spectra, and with regard to their origin and occurrence, divided into 10 classes. Of these only one class, namely, yellow substances with continued absorptions, have hitherto (as far as the author's acquaintance with literature reaches) been known to science; the spectra (and most of the bodies to which they belong)

* An abstract of these researches was communicated to the Royal Society by the Medical Officer, and was published on p. 253 et seq. of No. 108, vol. 17, of the Proceedings of that Society. An abstract also appeared in the Centralblatt für die Medizinischen Wissenschaften, January 1869.

of the other nine classes are here described for the first time. These researches show that specific absorption-phenomena are not, as has hitherto been believed, confined to the red, yellow, and green part of the spectrum, but occur, if not in the same variety, yet with the same or perhaps greater frequency in the blue, indigo, and violet part of the spectra, particularly of substances which present to the naked eye a yellow or orange colour.

The animal series of these substances claims particular consideration, on account of the important physiological and pathological questions which they concern: questions, for instance, as to the homologies of parts of the ovum, and as to the chemistry of the blood serum, and as to intestinal digestion, and as to the pathology of ovarian tumors, and generally as to cell-growth and secretion.

The spectroscopical observations were made with the methods and instruments which are described and figured by the author in previous reports, and which, for readiness and precision, he can strongly recommend to the attention of spectroscopical inquirers. To the author, at least, the spectroscope has become one of the most indispensable aids of inquiry in the laboratory. The diagnoses which it is capable of establishing between bodies of similar colours, or between bodies which by chemical reaction assume or yield similar colours, are striking and certain, and cannot be furnished so readily by any other mode of inquiry.

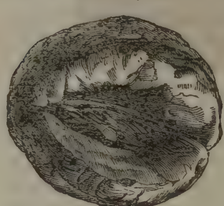
a.

On Ovario-luteine, the characteristic Yellow Ingredient of the Corpora Lutea of Mammals.

Corpora from ovaries.

The ovaries of cows and heifers were dissected, and corpora lutea from the size of a large filbert to that of a lentil removed. The large corpora had all what may be called a cap or a projection protruding over the round surface of the ovary. The larger they were the lighter was their colour. The large ones were yellow to orange, the small ones became red like cinnabar. Some came easily out of the tissue of the ovary, being attached only loosely by connective tissue; scraping rather than cutting was required to isolate them. Some contained a cavity filled with a clear yellow fluid. In one instance I removed this fluid with a pipette, and found it to measure about 3 cubic centimetres. A few minutes after its removal from the cavity it became firmly coagulated. The corpus was of equal thickness all round, the inner surface pale, white, and smooth, with many threads extended from wall to wall. There was no aperture in the corpus, which therefore represented a complete cyst. Other corpora came out of the ovaries with no less ease; but they were smaller and more solid to the touch, and contained a small cavity of the size of a pea, filled with yellowish coagulating fluid. The greater number of corpora, however, contained no cavity, but were quite solid, and in the place where a cavity might have been, and in my opinion was at an earlier stage of their growth, they showed stripes and streaks of white fibrous tissue. These corpora rarely had any protuberance. Smaller corpora were of darker colour, and adhered very firmly to the tissue of the ovary, drawing its sur-

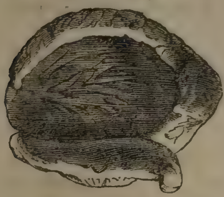
Cavity of corpus filled with fibrinous fluid.



Solid corpora.

Small corpora.

face inwards after the fashion of an umbilicus. The smallest corpora were dark red, and frequently quite buried in the substance of the ovary. The corpora, particularly the large ones, were surrounded by many blood-vessels, but in none of them was there ever seen effused blood, or coagulated blood, even to the smallest extent, or any residue or appearance which could have led to the belief that there had been at one time an effusion into its cavity, or near to its periphery. No crystals of any kind, particularly no so-called hematoidine crystals, were ever met with. Microscopically the corpora lutea, while fresh and large, consisted of many large bodies, so-called cells, with a nucleus each, and a great quantity of feebly-coloured *granular matter* in the material surrounding the nucleus. This granular matter became darker as the cells grew older, and shrank, until at last in very dark-red corpora the granular bodies were dark, strongly defined, and impenetrable to light, as if all matter except the coloured ingredient had been extracted from the body or cell, and the outer membrane, if any such was there, had been contracted around the pigment.



No blood or crystals found.

Microscope shows nucleated bodies.

Dark old bodies.

A number of the corpora were pounded and put into a steam-oven in a dish. They drew a considerable amount of juice, which was turbid and reddish, and was poured off. It gave a precipitate with nitric acid, which pink at first became greenish yellow. It gave a precipitate, then a solution with sulphuric acid, which became reddish brown on standing. With sulphuric acid and sugar it became beautifully purple, like the fat from blood corpuscles or cod liver oil, or cerebric acid. Its spectrum showed a band in green:

Pulp of corpora draws a juice on heating.

Reactions of this juice.

Purple test.

76 to 113 = 37, int. 10, cut off at 155.

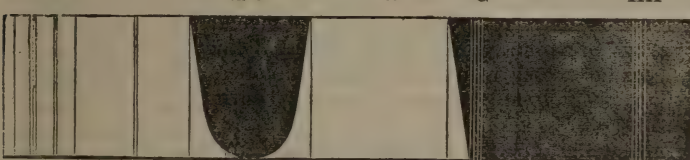


Diagram of Purple Test of Juice of Corpora.

More diluted with sulphuric acid the spectrum is: band 80 to 106 = 26, int. 4, cut off at 160. Blue splendid. Both observations made with Drummond's light. When this purple solution was poured into alcohol it either lost its colour when little in quantity, or when a larger amount was taken gave to the alcohol a smoky hue. The peculiar spectrum distinguishes this reaction from that of bile acids and cerebric acid. Hydrochloric acid gave no reaction in the watery juice, even on heating. The juice itself seemed colourless, as on filtration, which was very difficult, only a few drops of nearly colourless fluid passed. The colour of the turbid juice is therefore probably due to suspended particles, but the reaction seems to be due to both particles and fluid.

Diagnosis from bile acids.

The solid part of the corpora, when dry, was powdered and extracted with boiling alcohol of 85 per cent. by volume. A deep yellow solution was obtained, which was filtered on the steam-funnel, and immediately

Extraction of dry corpora lutea with alcohol.

became turbid. Subsequent extracts being added, the solution ultimately remained clear. The yellow solution before the spectroscope passed red, yellow, and green, until 85, where spectrum was decidedly cut off. Diluted with one-third of its volume of the same alcohol it exhibited two bands, one in blue and one in indigo.

Spectral analysis of alcohol extract.

Measurements of spectrum.

Obs. (*a.*) (1.) 110 to 123 = 13 Int. 2.
(2.) 134 „ 152 = 18 „ 1.
Obs. (*b.*) (1.) 107 „ 120 = 13
(2.) 128 „ 149 = 21

Possible third feeble band in violet, at about 170. End at 195.

After repeated clarification of the solution, and with the aid of Drummond's light, the following final observation was made :—

Obs. (*c.*) (1.) 106 to 122
(2.) 130 „ 150
(3.) 165 „ 179
End at 198.

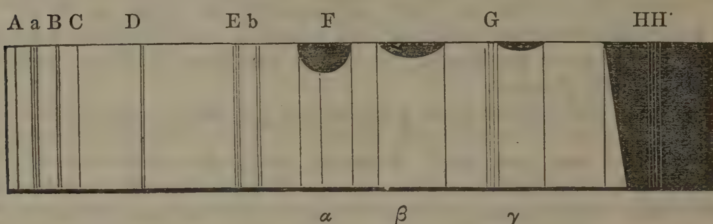


Diagram of Spectrum of Alcohol Extract of Corpora Lutea of Cow.

Turbidity by water.

The addition of a little water or of any watery reagent to the saturated alcohol solution caused a turbidity which did not dissolve on heating. The potash mixture alone became clear and formed a yellow deposit. Platinum tetrachloride, gold terchloride, and mercury perchloride produced no reaction, even on boiling. Neutral mercury nitrate caused a copious yellow precipitate, which on heating immediately, slower on standing, became snowy white. Mercury acetate produced a copious canary-yellow precipitate, which on boiling contracted, and left the fluid colourless.

Reactions with mercury nitrate and acetate.

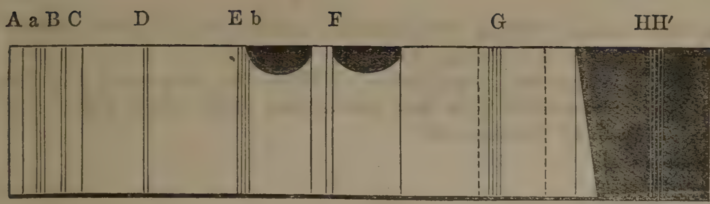
Reactions with acetates of copper, zinc, and lead.

Copper acetate produced a copious green precipitate, which became thicker on boiling, but the fluid remained turbid for days. The acetates of zinc and lead apparently produced no reaction at first, even on boiling, but on standing some days the mixture deposited all yellow matter as an oil at the bottom of the alcoholic solution. A solution of iodine in ammonium iodide produced no reaction.

Chloroform solution of luteine. Spectrum.

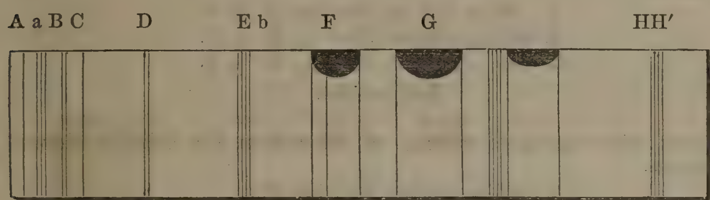
Chloroform extracted the yellow matter both from the fresh wet corpora and from the dry powder. The solution left the spectrum free to 85, when the blue was cut off. On continued dilution blue appeared, but there remained an absorption band, 93 to 110 = 17, int. 2, seen with gas-light. Drummond's light gave same measurement. On very cautious dilution a second absorption band, 119 to 136 = 17, int. 2, R. β, could be observed ; spectrum cut off at 175. Other reading of medium concentrated solution :—

(1.) 90 to 100 = 20.
(2.) 116 „ 137 = 21.
Cut off at 189.



As compared to the spectrum of the alcoholic solution, the bands of the chloroform solution were moved from 12 to 16 points of the scale towards the red end, and the third band was not certainly visible.

The ether solution, on the other hand, of which spectrum is here subjoined, resembles the alcohol solution, its second and third bands being moved a little more towards the violet end.



Reactions of luteine with nitric and sulphuric acid

The chloroform solution evaporated before the bellows left a residue, which was white at first, ultimately yellow. This residue with a drop of nitric acid became blue for a moment, then colourless. The chloroform solution with nitric acid became colourless at once without any blue appearing. The very peculiar odour of luteine which appeared most strongly during the evaporation of the chloroform, reminded me much of the odour of cancer juice. The yellow residue did not dissolve easily in cold alcohol, but required heating. By concentrated sulphuric acid it was coloured of a dirty green, which at the margin in the thinnest layers appeared blue. When a little sugar was added to the solution no purple appeared, from which it became probable that the reaction of the juice above described belongs to a matter not being luteine.

Odour like cancer juice.

Crystals of luteine.

When the alcohol solution is left to spontaneous evaporation, a semifluid fat-like matter remains, in which on standing crystals are deposited, while the fat loses nearly all its colour. The crystals are orange red in transmitted light. They can but imperfectly be isolated from the semi-fluid fat in the following manner :—The mixture is repeatedly shaken with absolute alcohol, in which the fat dissolves to a great extent, while the crystals are almost insoluble in it. What remains after decantation of the alcohol is repeatedly shaken with small portions of ether. The rest of the fatty matter now dissolves, and the crystals remain free, although deadened in appearance and corroded by the ether, which dissolves a portion of their substance. The crystals are washed on a filter with a little ether, pressed between paper, and dried.

Reactions of the crystals.

The crystals are soluble in chloroform with a yellow, in a concentrated state fiery orange, colour ; in absolute ether with a yellow colour, less easily than in chloroform ; in sulphide of carbon with a fiery red colour, which by dilution becomes orange yellow. Glacial acetic acid dissolves the crystals on heating only. Dilute acetic acid, dilute mineral acids, ammonia, caustic soda, do not dissolve the crystals. Nitric acid poured over the crystals produces a blue colour, which immediately

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passes into yellow. When dilute or concentrated nitric acid is added to the solution of the crystals in acetic acid, the blue colour is also produced, but disappears immediately. Neither the chloroform nor the ether or alcohol solution give any blue colour with nitric acid; the solutions are simply discoloured.

b.

Ovo-luteine, the characteristic Yellow Ingredient of the Yelks of Hens' Eggs.

Chloroform extract.

Yelks of hens' eggs were shaken with chloroform. On standing, a yellow solution settled, on which white vitelline floated. The solution, assumed to be saturated, had spectrum of three bands in blue, indigo, and violet.

1. 99 to 117 = 18; int. 2. R. α.
2. 125 „ 145 = 20; „ 2. „ β.
3. 155 „ 174 = 19; „ 1. „ γ.

End at 190.

Diluted with one-third volume of chloroform the solution showed spectrum—

1. 103 to 117 = 14; int. 2.
2. 126 „ 144 = 18; „ 2.
3. 159 „ 173 very feeble.

End at 196.

Again observed after standing 24 hours—

1. 103 to 117.
2. 126 „ 144.
3. 158 „ 172.

End at 200.

This solution shows the bands very well, and better than any of the following solutions in ether or alcohol. It is necessary to obtain the solution very brilliant by letting it stand, and filtering and decanting it repeatedly from deposits of aqueous matter.

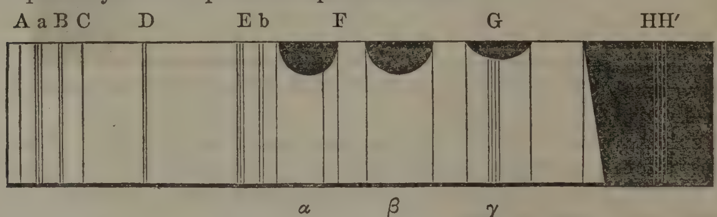

Diagram of Spectrum of Luteine from Yelk of Egg in Chloroform.

Ether extract.

The *ether solution* of the extract from yelk has a splendid yellow colour. In its saturated state one centimetre thickness cuts off the spectrum at 100 nearly. Much diluted there appears spectrum of bands—

1. 108 to 125 = 17; int. 2. R. α.
2. 134 „ 155 = 21; „ 2. „ β.
3. 168 „ 184 = 18; „ 1. „ γ.

End at 196.

More diluted the spectrum measured—

1. 110 to 125.
2. 135 „ 155.
3. 168 „ 184.

End at 205.

Diagram of Spectrum of Luteine from Yelk of Eggs in Ether.

Alcohol extract of yelks.

Yelk was boiled with alcohol of 85 per cent., and the filtrate separated on hot funnel. On cooling the solution immediately became turbid. In this turbid state it allowed the red and green of the spectrum to pass, although it was cloudy ; complete darkness began at 112. On being heated it cleared up, and now allowed bands to be observed—

1. 111 to 128 = 17.
2. 135 „ 155 = 19.

It remained questionable whether or not there was a third band in violet, but traces of it were only perceptible while the fluid was very hot.

On standing the alcoholic solution deposited a fatty matter, and became quite clear. It showed three bands—

1. 108 to 124.
2. 134 „ 152.
3. 167 „ 183.

End at 200.

Diagram of Spectrum of Luteine from Yelk of Egg in Alcohol heated.

Bands lose intensity in hot fluid.

When this clear alcoholic solution was heated the intensity of the bands was diminished to less than one-half, the third band becoming quite imperceptible. On cooling the absorption bands gradually re-assumed their former intensity.

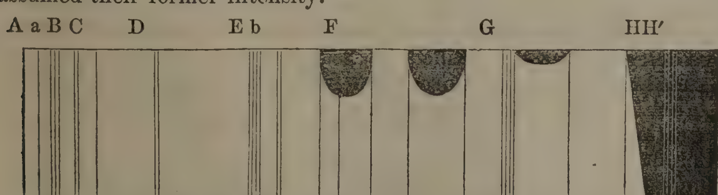

Diagram of Spectrum of Egg Luteine in Alcohol after cooling.

Nitrous acid absorbs more while hot.

This phenomenon is the reverse of the one I observed upon vegetable matters, which became darker in their bands by heating. The red vapours of nitrous acid also show a greater absorption by heating, the absorption lines augmenting greatly in number with the rise of temperature.

Comparison of spectra.

The bands of the heated luteine solution measured—

1. 110 to 126.
2. 137 „ 154.
3. 168 „ indistinct.

} Band appeared between gorgeous colours—bands of blue, indigo, and violet.

End at 196.

Displacements of bands.

The spectrum of the alcoholic solution of luteine from yelk is therefore identical with that of the ether solution of the same substance. The spectrum of the chloroform solution differs, however, in this, that its three bands are displaced by about 10 points towards the red end of the spectrum, although they retain almost exactly their position relatively to each other. Similar displacements of bands produced by different solvents upon the spectra of the same bodies are not unfrequently observed.

Comparison of Spectra of Luteine.

From Ovaries of Cows.	*From Hens' Eggs Yelks.*
Alcohol extract.	*Alcohol extract.*
1. 106 to 122 = 16 int. 2. R. α.	1. 108 to 124 = 16 int. 2. R. α.
2. 130 „ 150 = 20 „ 2. „ β.	2. 134 „ 152 = 18 „ 2. „ β.
3. 165 „ 179 = 14 „ 1. „ γ.	3. 167 „ 183 = 16 „ 1. „ γ.
End at 198.	End at 200.
Chloroform extract.	*Chloroform extract.*
1. 90 to 110 = 20 int. 2. R. α.	1. 103 to 117 = 14 int. 2. R. α.
2. 116 „ 137 = 21 „ 2. „ β.	2. 126 „ 144 = 18 „ 2. „ β.
3. Observed, but margins not defined.	3. 158 „ 172 = 14 „ 1. „ γ.
Cut off at 189.	End at 200.
Ether extract.	*Ether extract.*
1. 110 to 125=15; int. 2. R. α.	1. 108 to 125 = 17 int. 2. R. α.
2. 135 „ 155=20; „ 2; „ β.	2. 134 „ 155 = 21 „ 2. „ β.
3. 168 „ 184=18; „ 1; „ γ.	3. 168 „ 184 = 18 „ 1. „ γ.
	End at 196.

There is no doubt that if all spectra could be measured at one and the same time, and with one and the same intensity of light, the coincidence of the data would yet be greater than it is. Upon a comparison of all the data, and taking into consideration the chemical reactions above described, we are justified in assuming that :—1. The spectra of the various extracts from the corpora lutea are identical with those of the several extracts from hens' eggs. 2. A fortiori the body producing the spectra in the extracts from the corpora is chemically identical with that producing the spectra in the extracts from yelks. 3. This body is a yellow crystallizable substance which has not hitherto been defined, to which I attribute the name of luteine.

This body has, however, repeatedly engaged the attention of inquirers. Thus Holm, under the guidance of Städeler, isolated it, and described

(Erdmann's Journal, vol. 100, p. 142) most of its properties, excepting the spectroscopical ones, but believed it to be hematoidine. But *luteine* differs entirely from *hematoidine*. Luteine is the specific physiological product of a certain normal cell-formation which builds up the corpora lutea. Hematoidine is an abnormal product of pathological processes, or at all events an accidental formation derived from effused blood out of the circle of vital action. Luteine is deposited in granules within cells, a product of their chemical life ; hematoidine is deposited in crystals and irregular masses in the midst of effused and decomposing blood. The idea that the yellow or red matter of the corpora lutea was hematoidine originated from the circumstance that corpora lutea sometimes, in a few animals such as sows, and sometimes in women who have died of disease, contain extravasated blood in their centre, and in this a few crystals of hematoidine. This blood is a pathological formation, or if not, at all events an abnormal one. For in the hundreds of ovaries from cows, sheep, or other animals which I have dissected, I have only twice found any effused blood in the corpora lutea, and only once in any other part of the ovaries than the arteries and veins. Bischoff (Entwicklungsgeschichte der Säugethiere, p. 32, et seq.) gives a description of the corpora lutea to which I assent in all its features. He says nothing of the bloodclot which has latterly been so often alluded to in relation to hematoidine, and which has actually been figured by Henle (Anatomie des Menschen, Vol. II. p. 478, fig. 372, ref. 5) as situated in the cavity or in the midst of the corpus luteum, already approaching its natural greatest size. However often such abnormal products may have been observed by others, the hematoidine crystals contained in the interior of these little ovarian apoplectic effusions are things which are quite different from the granular luteine contained in the cells of the corpora lutea, even of those corpora lutea which may contain such a sanguineous effusion, though they may be lying side by side. Still less probability has now the view originally propounded by Paterson (Edinb. Med. and Surg. J., Vol. 53, No. 142, 1840, p. 1, and No. 45, p. 390), that the corpus luteum was the product of the transformation of an effusion of blood between the two layers of the Graafian follicle. The corpus luteum is a new growth from the membrana granulosa of the follicle, in the formation of which extravasated blood has no share, and the development of which it could only impede. Städeler (Erdmann's Journ., Vol. 100, p. 148) investigated the nature of the yellow matter in the yelks of eggs, probably in connexion with the studies of Holm. He did not obtain a crystallized body, and came to the conclusion that the yellow matter was either hematoidine (such as Holm had defined it), or some very nearly related body. The spectral phenomena of the extracts from yelk did not engage his attention.

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References to literature.
Diagnosis from hematoidine.

Luteine has no chemical or physical relation to hematoidine, or any other derivate of hematocrystalline. The latter when treated with sulphuric acid all yield cruentine, with a variety of modifications, and peculiar absorption spectra, several of which I described in the last Report. Luteine becomes blue, then green, with sulphuric acid, and then shows no spectrum at all like anything obtained from blood. Luteine has its absorption bands in blue, indigo, and violet, while all derivates of hematocrystalline have their absorption bands in red, yellow, and green, hematine alone just leading with its last band into blue. The hematine nucleus of hematocrystalline is very difficult to destroy by chemical agents, and even strong reagents produce changes so to say only upon its surface. Luteine is easily and permanently altered by the same agents. Nitric acid transforms all relations or derivates of hematocrystalline

with difficulty into intense yellow substances; but luteine is by nitric acid and some nitrates immediately transformed into a colourless or white product. The crystals of luteine have no similarity either in shape, size, or appearance, to those of hematoidine; their facile solubility in ether, chloroform, and alcohol, distinguishes them entirely from hematoidine, which is quite insoluble in these agents. When Valentiner (Günsburg's Zeitschrift N. F. 1, 46, 1859) stated that he had extracted "hematoidine" from gallstones by means of chloroform, he mistook cholophæine or bilirubine for hematoidine. Cholophæine differs as much from hematoidine on the one as from luteine on the other hand.

Diagnosis of luteine from cholophæine.

The mistake of Valentiner was repeated more formally by Robin and Riche (Compt. Rend. de Séances de l'Acad. de Sc. Tome 41, Séance du 1ER Octob. 1855), who obtained a quantity of cholophæine from a cyst in the liver, and by the aid of three elementary analyses, which clearly show that they referred to cholophæine, came to the conclusion that they had to deal with hematosine (the body which we usually term hematine) which had lost its amorphous character, and its iron, taken up an atom of water, and become crystallized hematoidine. It is only necessary to compare the reaction of Robin and Riche's hematoidine crystals with the reaction of cholophæine which I have described, in order to be quite sure that they had cholophæine before them. On the other hand, none of the physical or chemical signs of their crystals are identical with those which Virchow has given as being characteristic of hematoidine.

What ultimately remains of hematoidine, when the various bodies which have been ranged under its name are eliminated, is not difficult to tell. Hematoidine is probably decomposed hematocrystalline. Its crystals are most likely pseudomorphoses of the original forms of hematocrystalline, consisting of the albuminous body intimately mixed with the hematine which before decomposition constituted the soluble and crystallizable hematocrystalline. The amorphous hematoidine on the other hand is so little defined, that we cannot at present receive it as a characterized chemical object.

I therefore add to the conclusions above given yet the following:—

4. Luteine differs entirely from hematoidine on the one and from cholophæine on the other hand, and must not, and after this exposition cannot, any longer be confounded with either of them. 5. The bodies described by Holm and Städeler under the name of hematoidine are not hematoidine but luteine. 6. The bodies described by Valentiner and by Robin, Riche, and Mercier under the name of hematoidine are not hematoidine but cholophæine or bilirubine. 7. Hematoidine is a useful expression for certain microscopical crystals and bodies occurring in effused blood, the substance of which has not as yet been chemically isolated or defined.

The discovery of luteine in the ovaries, and of its identity with the yellow matter of the yelks, may suggest some revision of the doctrine of the homologies between the various parts of the ova of mammals and the eggs of birds, and assist in elucidating the very obscure physiology of the corpora lutea. For, though it is easy to tell the mechanical purpose of these growths, it is difficult to explain the object of their peculiar chemical ingredients.

c.

Butyro-luteine, the yellow ingredient of Butter.

Yellow and white butter.

It had never to my knowledge been asked in scientific inquiries, to which particular circumstance butter owed its yellow colour. Butter,

particularly during winter, might assume a perfectly white colour, and then the prejudice of the producers or consumers termed it "poor." The vendors to avoid the effect of this error had recourse to artificial colouring ingredients. We shall see in the sequel how closely the dyeing agents used for this purpose, namely, the juice of carrots, and of the orleans berry or annatto, resemble, in their optical phenomena at all events, the natural butyro-luteine of good healthy butter.

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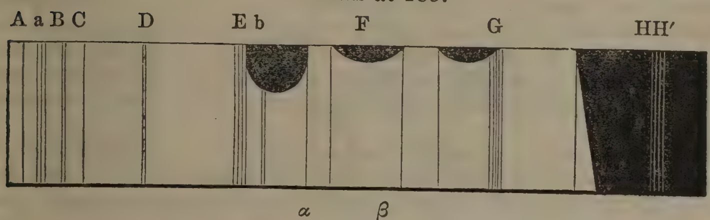
Dyed butter.

St. Thomas's Hospital butter.

In August last I obtained a small quantity of the butter which is regularly supplied to St. Thomas's Hospital from a farm in the neighbourhood of London. It had a fine "rich" yellow colour, a pure fresh taste, and had been mixed with salt and formed into pats. On being fused in hot water it remained opaque, from the salt, water, and caseine; it was therefore mixed with an equal volume of chloroform, and the solution filtered from the deposit. This solution yielded spectrum—

1. Band in blue, 90 to 108, Int. 2. R. α.
2. " indigo, 116 " 137, " 1. " β.
3. Third feeble band.

Ends at 189.



Intensity Diagram of Spectrum of Butter in Chloroform.

Another quantity of butter was now fused in a glass vessel, heated until all the water had boiled away, and the salt and caseine had been deposited, and filtered through paper on a heated funnel. In a test tube it showed a fine golden colour, and before the spectroscope it exhibited both the α and β bands of luteine, but moved by about 20 points more towards the violet end.

1. 110 to 123.
2. 134 to 153.
3. 159 to 173, very feeble.

End at 196.

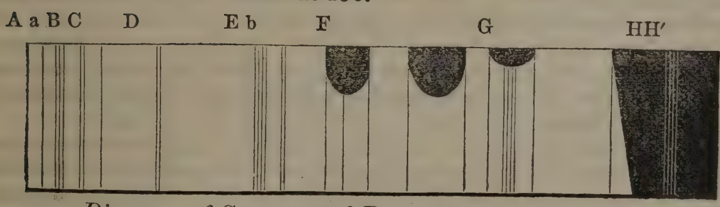


Diagram of Spectrum of Butter clarified and fused.

As the butter cooled the bands became more intense; the higher it was heated the less was the absorption exhibited by the bands. The third band was not visible while the butter was very hot, but became clearly visible a moment before it congealed.

d.

Cysto-luteine in the fluid contents of an Ovarian Cyst.

Luteine in fluid of an ovarian cyst.

The tumor came from a cow; the entire ovary was one large cyst measuring three inches in circumference and two inches in length. It

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contained a yellow fluid, which amounted to 35 cubic centimetres by measure. A slight deposit of fibrine of the size of a pin's head was observed in it; it fluoresced green.

Spectrum: In thick layers red, yellow, and green, to 87, appeared, where the spectrum was suddenly cut off. Diluted with half water bands appeared—

1. In green 92 to 108=17; Int. 5; R. α.
2. In blue 115 „ 130=15; „ 3; „ β.

With gaslight it remained questionable whether or not there was a third band. Drummond's light with a layer of the natural solution 1 ctr. in thickness gave spectrum—

1. 92 to 108=17; Int. 5; R. *a*.
2. 116 „ 138=22; „ 5; „ β.
3. 150 „ 163=13; „ 1; „ γ.

End of violet at 195.

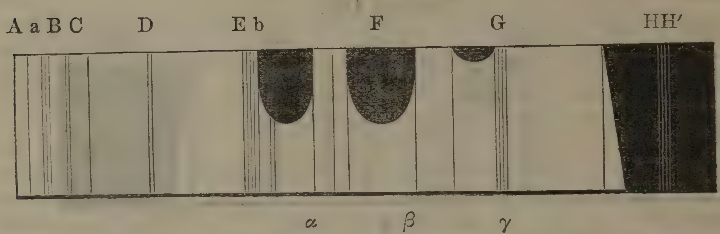

Diagram of Spectrum of Luteine from Ovarian Cyst.

The serous solution therefore yields the same measurements as the chloroform solution of ovario-luteine; it therefore probably contains the same kind of luteine as the corpora lutea. When I attempted to extract it the following was observed:—The fluid was so albuminous that on heating it became solid in the tube. Alcohol precipitated an immense quantity of albumen of a white colour, and itself assumed hardly any yellow colour. The luteine therefore adheres strongly to the precipitated albumen. I therefore preserved the mixture for a future favourable opportunity, when it may be treated together with larger quantities of similar matter.

Remarks.

The above observation, though single, appears to me particularly interesting; and it will be very important to ascertain whether the same holds good of ovarian cysts generally. The luteine contained insolubly in the cells of the corpora lutea is here dissolved in an albuminous liquid. If the deposition in granules was accompanied with the presence of fat in granules, the solution is distinguished by the absence of all fat. While together with fat luteine could be easily extracted by alcohol, it could scarcely be extracted by means of this agent from the albuminous solution. The cells of the corpus luteum had perished, or not been formed; the limitary membrane of the Graafian follicle had, however, apparently preserved a portion of its specificity as regards the chemical nature of its secretion. Fibrine, present in large quantity in the corpus luteum, was here only slightly represented; albumen prevailed, accompanied by the soluble alkaline phosphates, which also occur in abundance in the corpora lutea. The substance which I have above described as apparently attaching to the white corpuscles of the blood was not diagnosed in the serous fluid, and was probably absent.

e.

Seroluteine from Animal Blood.

Seroluteine from animal blood.

It has long been supposed that the serum of the blood contained a yellow colouring matter, as it preserves a yellow colour, notwithstanding all measures which may be adopted for its clarification. It was surmised that this was colouring matter of bile, but this was negatived by direct research. Cholophæine occurs in the serum only in diseases, particularly obstructive diseases of the liver, or those which cause great congestion of the liver from a distance, like pneumonia and puerperal fever. Normal blood has never been found to contain cholophæine. In 1835 Martial Sanson published an essay on the colouring matters of the blood (Journ. de Pharm. 21, 420), in which he announced the existence of a yellow colouring matter by the side of the ordinary red ingredient, but he did not state that it was contained in the serum. He obtained it in the following matter :—Dried ox-blood was powdered and boiled in alcohol of 18°, whereby a little grease and some salts were removed. The powder was then washed with distilled water. The evaporation of these washing waters yielded a residue of deep yellow colour and strong salty taste. This residue was now dissolved in alcohol of 18°, afterwards in alcohol of 36° containing some ether; it was next filtered from albuminous and saline particles, and yielded ultimately a liquid which had a deep golden yellow colour.

Sanson's "matière jaune."

The blood thus deprived of its soluble salts and of a portion of its yellow matter, was dried, and repeatedly exhausted with boiling alcohol of 36°. The three first decoctions yielded on further treatment cholesterine and a small quantity of a brown matter, from which seroline could be separated. The fourth and subsequent decoctions were evaporated to dryness by themselves and left a mixture of three substances. From these cold water extracted a *yellow matter*, warm alcohol a fatty substance, and there remained a thin layer of bluish matter, which having been washed with alcohol and ether of temp. 40° C. dissolved in boiling alcohol with a fine *sky-blue colour*.

Properties of the "matière jaune."

Properties of the Yellow Matter.—It is soluble in water, alcohol, ether, and fats. The concentrated acids and alkalies do not change it while cold. When dry and in bulk its colour is orange yellow. By chlorine it is discoloured, but the liquid contains no iron. It is the colouring matter to which blood-serum owes its yellow colour, and it adheres to the fats which are extracted from blood by alcohol. As it easily combines with other matters it is very difficult to obtain it perfectly pure.

Properties of the "matière bleue."

Other proceeding for obtaining, and Properties of, the Blue Matter.— Blood is precipitated by basic lead acetate, the precipitate is dried, and boiled with alcohol of 36°. The liquid quickly assumes a blue colour. The first decoctions become turbid on cooling, and deposit a large quantity of fat, which carries the blue matter down with it; but after a time a tincture is obtained which remains transparent, and from which the blue matter can be isolated by the process stated above. When pure the blue matter is insoluble in cold alcohol, ether, and water; it is a little soluble in boiling alcohol, but is precipitated on cooling. The concentrated acids do not change it; the very concentrated sulphuric acid decomposes it. Ammonia by itself does not change it. Ammonia added to the alcoholic solution causes it to assume a greenish colour, and the subsequent addition of an acid restores the blue colour; chlorine discolours it; the fluid contains no iron.

Sanson states that Chevreul, Le Canu, and Lassaigne have met with

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a similar blue matter in the blood of hysteric persons. He claims for himself the merit of having shown this matter to be a normal constituent of blood. F. Simon and other subsequent investigators could not find the blue matter again, and of the yellow they could not form a pure preparation or a clear idea. The production of a blue colour from blood by means of ozonised ether has invested this question with a new interest. To this we may add the question after the origin of the yellow matter in cholera urine, which with nitric acid yields a red and blue product, choleraic urorubine, and choleraic urocyanine, and the entire question of yellow, blue, and red matters observed in urine by a number of chemists. Seeing that luteine from eggs and ovaries also yields a blue colour by nitric acid, surmises are naturally aroused and tested experimentally.

Treatment of serum for luteine.

I caused a quantity of sheep's blood to be collected in a glass vessel in the slaughter-house, and to be placed in a secure corner. After 24 hours standing I carefully decanted the serum; this was now allowed to stand twice 24 hours in high cylindrical glass vessels, and the supernatant clear serum was drawn off from the deposit of blood corpuscles by means of a syphon. It was then filtered repeatedly through many folds of finest filtering paper, but by no means it could be made bright or translucent, it always retained a certain degree of opacity like ground glass. It was yellow, somewhat reminding of red. In layers of from $\frac{5}{8}$ to $\frac{3}{4}$ inch it showed the blood spectrum before the spectroscope, and with the most powerful Drummond's light which I could produce it exhibited the band α of luteine.

105 to 117=12 ; Int. 2 ; R. α. Blue interval to 125.

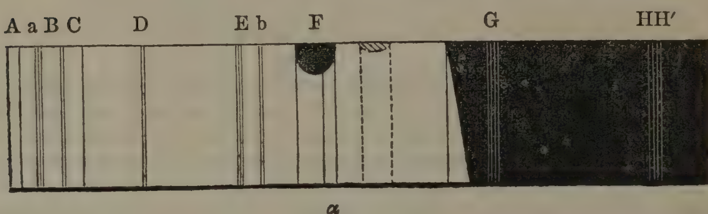


Diagram of Seroluteine. (*Blood-bands omitted.*)

(See also Plate V., fig. 10.)

I suspected at times the existence of a second band, at others all seemed to fuse into continued darkness. If the serum is diluted so that the absorption due to hematocrystalline is removed sufficiently so as not to interfere, the luteine bands become imperceptible. I have faintly indicated a second band on the plate, but I am not absolutely certain about it. I believe, from repeated experiments, that serum cannot by any means be perfectly freed from blood corpuscles. I have never seen serum without the blood-bands in the spectroscope, and it is not impossible that a great part of its yellow colour is due to these corpuscles. Although the above spectrum has been indubitably seen and scrutinized by me during an entire afternoon, I have failed in other specimens of serum to find it, and therefore it is possible that it may be an accidental ingredient. I have not yet succeeded in extracting it from serum, and believe that even if luteine were proved to be certainly and always present, the extraction would be exceedingly difficult. For I did not succeed, by a simple process of extraction

with alcohol, in obtaining any luteine from serum of an ovarian cyst, in which this substance was unquestionably present in large quantity; so strongly does it adhere to precipitated albumen.

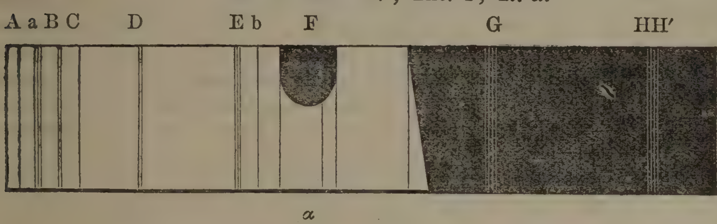
f.

Intestino-luteine from the Yellow Evacuations of sucking Infants.

Intestino-luteine from evacuations of sucking infants.

These fæces when healthy are of a golden yellow colour, semifluid consistency, and a slight odour of warm sour milk. It is difficult to obtain them without admixture, but their constituents cannot be mistaken. Mixed with alcohol in excess a great amount of a body having most of the properties of caseine falls down in flakes, while other matters dissolve, amongst them nearly the whole of the yellow coloured ingredient. The dilute solution exhibits an absorption band in blue, 103 to 115, which when the layer of fluid is made thicker gains in width, and becomes

101 to 118=17; Int. 4; R. α.



Intensity Diagram of Intestino-luteine.

Last reading 102 to 118. Only one band could be seen distinctly; a second band was suspected at 126 to 142, but from 130 every part to violet was already very dark. Chloroform and ether solution must be examined with a view to determine the question whether or not there is more than one band.

The alcoholic solution on standing became a little more red, but in thin layers was still yellow. It deposited a quantity of white cholesterine in crystals. After standing in a stoppered bottle for a period of six weeks it still showed the same spectral phenomena as at first.

Comparison of adult human excretions.

I compared some chloroform extract of dried adult human fæces which had been kept during several years, and had been repeatedly filtered from a precipitate which formed at intervals. The extract was yellow, showed no absorption band anywhere, and passed light to 167.

Physiological considerations.

Physiological considerations.—It has hitherto been generally accepted as a matter requiring no proof that the fæces of infants and adults owed their colour to an admixture of colouring matter of bile. Of course in the case of an omnivorous adult the accidental ingredients were also taken into account, but in infants the colour was to be derived from pure cholophæine. The above observation shows this surmise to be quite unfounded. Cholophæinates which are soluble in alcohol possess no absorption bands; the yellow extract of the evacuation of infants does not yield the reaction of cholophæine or bilirubine, and consequently, in the case of infants at the breast, cholophæine is not excreted. But another circumstance aided this erroneous belief, and this leads us to some pathological considerations. When infants fed upon milk become disarranged, their evacuations soon become green, and this phenomenon

Pathological considerations.

in itself is a sign of digestive disturbance. Now it was assumed that this green colour was due to biliverdine which had been produced from the bilirubine by the diseased process. It is, however, now very doubtful whether the green colour of diarrhœic fæces of infants, and of the meconium of the fœtus, is really produced by biliverdine. It is more probably a mixture of intestino-luteine with a peculiar blue product of its oxydation, or a green simple product of that oxydation.

Origin of intestino-luteine.

The origin of intestino-luteine itself it is not difficult to surmise. It might be derived from the milk, which, as I have shown above, contains in its butter globules a quantity of luteine with three bands. This luteine would therefore be required to undergo a considerable change before it could become intestino-luteine. But we have a much nearer source for this substance, and that is the mucous membrane of the intestine itself. The intestinal juice has a wine-yellow colour, as has been shown by the experiments of Thiry, lately confirmed by Quincke. It is probable that this colour is caused by the luteine here alluded to. The green colour of diarrhœic fæces might therefore be caused by a change in the secretive power of the membrane, or by an influence of the contents of the intestine upon the luteine secreted as such. Physiological inquirers, who have leisure to repeat the experiments of Thiry, should therefore be careful to place the intestinal juice before the spectroscope, in order to decide whether or not it possesses the absorption band of lacto-luteine above described.

B. *Vegetable Series.*

a.

Yellow Substances showing Spectra with continued Absorption of Blue, Indigo, and Violet, without detached Bands.

Such are exhibited by the yellow immediate principles of the following vegetable matters :—

French berries. (Chrysorhamnine, Xanthorhamnine.)
Weld or dyer's weed. (Luteoline.)
Quercitron. (Quercitrine.)
Turmeric. (Curcumine.)
Purrée. (Euxanthic acid.)
Careopsis lanceolata.
Heliochrysum bracteatum.
Viola lutea.
Acacia decurrens.
Helianthus macrophylla.
Berberis Darwinii.
Gnaphalium fœtidum.

French berries.

French Berries.—These berries are the fruit of several species of rhamnus. They differ in size and construction, but on an average are of the size of peas, and wrinkled all over their green surface ; they contain a number of small hard seeds, and have a disagreeable bitter taste. Of the four varieties of these berries which occur in trade I had only one, the real "graines d'Avignon," at my disposal ; the Persian, the Levantine or Turkish, and the Spanish berries are not easily obtained. The French berries come from rhamnus infectorius. The yellow matter obtained from a large light coloured variety of berries by Kane, chrysorhamnine, had the composition $\mathrm{C}_{23}H_{22}\mathrm{O}_{11}$. It was of golden yellow colour, insoluble in water, soluble in ether. By pro-

Chrysorhamnine and Xanthorhamnine.

longed boiling with water while exposed to air it absorbed 1 H_2O and $2O$, and was transformed into xanthorhamnine $C_{23}H_{24}O_{14}$. This latter is soluble in water, but insoluble in ether; it is present, ready formed, in the dark brown variety of berries.

The watery or alcoholic solution of xanthorhamnine presents a continuous absorption of the blue end of the spectrum, without any detached bands. A saturated watery decoction of bruised berries was cleared up by alcohol. It passed all colours from red up to 107. Diluted +1 the absorption receded to 121; diluted +2 to 130; and 3 to 147; diluted to very pale yellow to 170.

Weld or dyer's weed.

Weld or Dyer's Weed (*Reseda luteola*).—Weld is now nearly obsolete as a dye, picric acid having taken its place. The entire plant is pervaded by a yellow colouring matter, which is extracted by decoction. This substance by its discoverer, Chevreul, has received the name of "luteoline." It crystallises in yellow needles, which sublime unchanged, are less soluble in water than in alcohol and ether, and have an acid character and reaction.

Luteoline.

In a decoction of weld greenish yellow flakes are deposited, consisting of luteoline and other matters in chemical combination. The filtrate is reddish yellow, and shows the general absorption of all yellow substances, namely obscuration of the violet, indigo, and blue parts of the spectrum to 138. Diluted it passes all colours to 160. By no treatment could I obtain separate bands; but as the solution seems to contain a red colouring matter as well as luteoline, the experiment should be repeated upon pure luteoline.

Quercitron.

Quercitron.—This is the bark of an oak tree of North America, quercus nigra or tinctoria. A preparation sold at the drysalters is termed extract of quercitron or "flavine." I have not been able to ascertain the manner in which this is produced. Possibly it is an impure preparation of the substance called by Chevreul "quercitrine," namely, the deposit which forms when a decoction of the powdered bark is allowed to stand for some days. Bolley believed that this consisted of quercitric acid, $C_{16}H_{16}O_9$, H_2O. But Hlasiwetz (Ann. Chem. 112, 107) showed its formula to be $C_{29}H_{30}O_{17}$. I produced a boiling watery solution of the flavine, which was reddish and turbid. Its spectrum was cut off at 130 by a solution of the same tint as one of luteoline which cut off the spectrum at 135. The visible blue had a violet tinge. On dilution the absorption receded to 135; diluted +2 to 140; +3 to 145; +4 to 169. At this point it was only pale yellow. When still more diluted to quite pale yellow the entire spectrum to 188 passed. No bands were detached at any time.

Flavine.

Quercitrine.

Turmeric, curcumine.

Turmeric.—This substance, the root of yellow ginger, Curcuma longa, contains a yellow dye, curcumine, easily soluble in alcohol. A translucent solution passed red, &c., to 112; diluted blue to 117; more diluted to 125. Again diluted with alcohol a hazy violet appears to 146; more diluted indigo and violet to 185. No bands were detached at any time. But as the extract contains a fluorescent substance which exhibits a green colour in the cone of sunlight, (it is not proved that curcumine itself is that fluorescent substance,) the absorption of the blue and violet may be partly due to this matter, and not to the yellow dye only, which might possess bands; but the bands might disappear before the fluorescent body is sufficiently diluted to let any light at all pass in blue and violet. Turmeric becomes brown by alkali, and is used as a test for alkalis in chemistry.

Fustet obsolete.

Fustet, or *fiset-wood*, the wood of Rhus cotinus, does not seem to be used in dyeing any more; I could not obtain any at the drysalters.

Purrée or Indian yellow.

Purrée or Indian yellow is a pigment of uncertain origin, probably the juice of a plant which is evaporated with magnesia. It contain *euxanthic acid* $C_{21} H_{18} O_{11}$. The solution of this acid is feebly coloured, and has no particular bands. Its dyeing qualities appear best in combination with bases, particularly magnesia. The pigment which I obtained in the colour shops had been treated in this country, and was in thin cakes, not the roundish lumps of commerce.

The alcoholic extracts of the following *yellow flowers* also yielded spectra with continuous absorption of the blue end, without any bands.

Careopsis lanceolata.

Careopsis lanceolata.—Solution reddish-yellow, saturated. Cut off at 72; gradually to 100, where dark; diluted one-half recedes to 128; diluted two-thirds to 140. Diluted to pale yellow the entire spectrum passes. No bands at any time.

Heliochrysum bracteatum.

Heliochrysum bracteatum.—Orange yellow solution. Cut off gradually at 102. Diluted + 1 recedes to 124; + 2 recedes to 135; + 4 to 162; + 8 to 195. No bands at any time.

Viola lutea.

Viola lutea.—Light greenish yellow solution. Cut off at 129. Diluted + 1 recedes to 145; + 2 to 165; + 3 no further recession takes place, and no band is developed. The solution is now only palest greenish yellow.

Acacia decurrens.

Acacia decurrens.—Light greenish yellow solution. Cut off at 134. Diluted + 1 recedes to 148; + 2 to 155; + 5 to 163. The solution is now only palest yellow, + 10 to 170. Hardly coloured now; the matter which cuts off is perhaps colourless.

Helianthus macrophylla.

Helianthus macrophylla.—Solution pale yellow. Passes entire spectrum to 177, even in feeble light. No bands. Observation not conclusive; more concentrated solution to be examined.

Berberis Darwinii.

Berberis Darwinii.—Passes entire spectrum to 189. Questionable whether bands; more concentrated solution required, for which there was not enough material.

Gnaphalium fœtidum.

Gnaphalium fœtidum.—Cut off at 144. Diluted + 1 recedes to 160; + 2 to 165. No bands detached. Rest of spectrum very brilliant.

b.

Yellow Substances showing Spectra with a single Absorption Band.

Yellow wood.

Yellow wood, or *fustic*, is the wood of a kind of mulberry tree, *morus tinctoria*. It contains *moritannic acid*, $C_{18} H_{16} O_{10}$, which is the carrier of the tinctorial power, either free or in combination with calcium. To test its spectrum I made a decoction of powdered yellow wood, and evaporated the watery solution after filtration on the steam bath. After 24 hours standing an orange coloured precipitate, a mixture of the acid and its calcium salt, had deposited. Both the mother liquor and the solution of the isolated deposit presented the same spectral phenomena. The concentrated solution cut off the blue and violet and a portion of the green part of the spectrum.

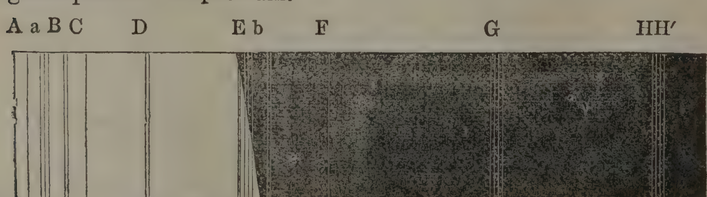


Diagram of Spectrum of Yellow Substances in general.

This absorption, common to all yellow coloured substances, I have also represented in fig. 1, plate I. But on dilution the absorption receded to 130, leaving a detached very pale band.

100 to 115=15; Int. 2; R. α.

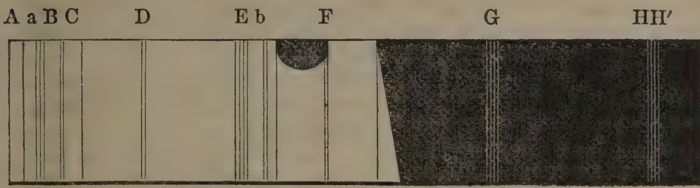


Diagram of Spectrum of Moritannic Acid.

See also Plate I., fig. 2.

I was not able to determine with certainty whether there was not a second band, as the solutions were always somewhat turbid, and the limits of this research did not permit me to follow the subject further. As, however, there are two analogous bodies, the one lactoluteine, already described, and the other the yellow colouring matter of the flower of the calceolaria, which possess but one absorption band in blue, and on further dilution do not exhibit any other detached absorption, I take confidence from these analogies to believe that moritannic acid also possesses but one absorption band.

Calceolaria.

Calceolaria.—The yellow variety of this esteemed flower yielded a cold alcoholic extract of a splendid *orange* colour, which exhibited a single absorption band in blue.

1. 103 to 118=15; Int. 3; R. α.

Sharply cut off at 125.

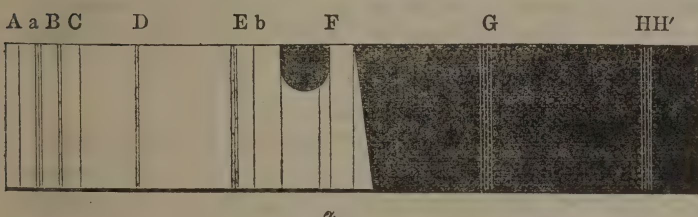


Diagram of Luteine of Calceolaria.

See also Plate I., fig. 3.

On further dilution violet to 145 appeared, the band α disappeared, and no new detached band was visible anywhere.

c.

Two-banded Luteine Spectra.

Yellow Vegetable Matters which show Spectra very much resembling that of Animal Luteine, but having probably Two Bands only.

Crocus or saffron.

1. *Crocus or saffron*, the stigmata and parts of the styles of a liliaceous plant, contains crocine, $C_{58} H_{84} O_{30}$ (?) It occurs also in the fruit of Gardenia grandiflora. Concentrated sulphuric acid transforms

crocine into an indigo blue, later into a violet substance. Boiled with dilute acids it is split up into crocetine and sugar.

$$\underbrace{C_{58}H_{84}O_{30}}_{\text{Crocine.}} + 5\,H_2O = \underbrace{C_{34}H_{46}O_{11}}_{\text{Crocetine.}} + 4\,\underbrace{C_6H_{12}O_6}_{\text{Sugar.}}$$

Crocetine retains the principal dyeing properties of crocine, and its reaction with concentrated sulphuric acid.

A hot or cold alcoholic solution shows two bands in blue and indigo.

1. 114 to 135=21. Int. 4. R. α.
2. 145 „ 165=20. „ 4. „ β.

End at 184.

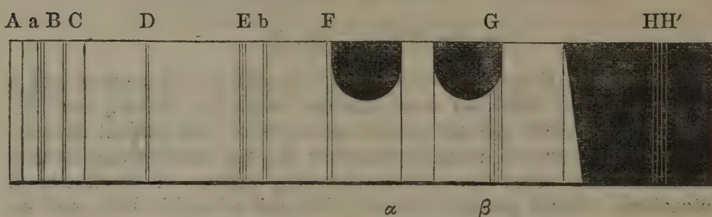


Diagram of Spectrum of Crocine.

See also Plate I., fig. 5.

In this spectrum the band β is placed more towards the violet end than in any other yellow solution I have yet examined. It just overlies the group of lines termed G; only in Verbascum phlomoides, plate III., fig. 2, does the second band just touch G.

Helianthus annuus, Sunflower.

2. *Helianthus annuus*, Sunflower.—A small flower of this kind, from St. Thomas's Hospital gardens, gave a yellow but turbid water extract. The alcohol extract, however, was clear, and of a splendid yellow colour. It showed spectrum—

1, in blue, 109 to 125=16. Int. 5 R. α.
2, in indigo, 136 to 157=21. „ 4 „ β.

Cut off at 172.

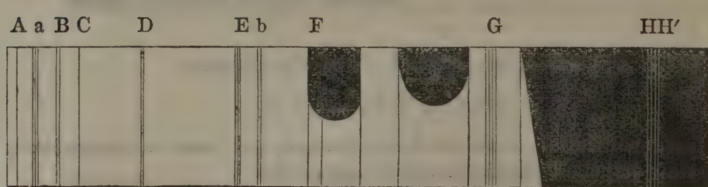


Diagram of Spectrum of Helianthus, yellow.

See also Plate I., fig. 6.

Much diluted, and with bright oxyhydrogen light, violet extends to 200, and there is probably no third band present.

Leontodon taraxacum, Dandelion.

3. *Leontodon taraxacum*, Dandelion.—The whole plant is officinal; in the Pharm. Brit. the root only. Alcohol extract of the flower, concentrated, is cut off at 105. Diluted bands appear.

1. 110 to 124=14. Int. 3.
2. 130 to 153=23. „ 4.

Suspected band begins about 166, if present. Remarkable that the second band is of greater intensity than the first.

More diluted, and with strongest Drummond light, the third band seems possible from 160 to 179. End at 205.

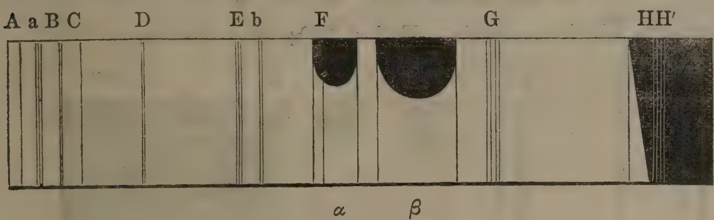


Diagram of Spectrum of Taraxacum—yellow.

See also Plate I., fig. 7.

Hieracium pilosella.

4. *Hieracium pilosella,* yellow composite, from St. Thomas's Hospital gardens. Cold alcohol extract.

1. 110 to 125=15. Int. 3. R. α.
2. 135 „ 155=20. „ 3. „ β.

End at 190.

No third band appears on further dilution.

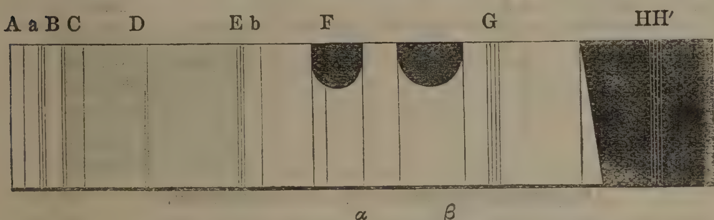


Diagram of Spectrum of Hieracium—yellow.

See also Plate I., fig, 8.

Gazonia elegans.

5. *Gazonia elegans.*—Flower orange, with black and white spots inside of petals. Has a white juice like Leontodon. Splendid deep yellow cold alcohol extract, not so orange as that of calceolaria.

1. 105 to 128=23. Int. 4. R. α.
2. 137 „ 158=21. „ 4. „ β.

End at 169.

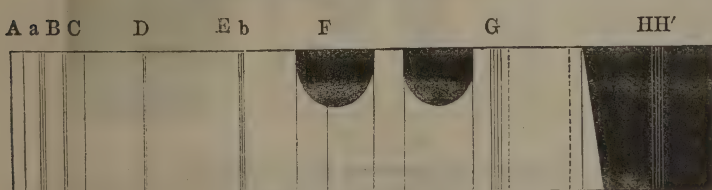


Diagram of Spectrum of Gazonia.

See also Plate I., fig. 9.

More diluted, violet is prolonged to 195, but a third band cannot certainly be distinguished. Stronger light and more solution allows a problematical shade 168 to 187 to be distinguished.

Hypericum oblongifolium.

6. *Hypericum oblongifolium.*—Solution yellow, made a deposit from which it was filtered.

1. 113 to 125=12. Int. 4. R. α.
2. 136 „ 152=16. „ 3. „ β.

Last term a little uncertain. End at 160; after dilution at 184.

Diagram of Spectrum of Hypericum—yellow.

See also Plate I., fig. 10.

Acacia leprosa.

7. *Acacia leprosa.*

1. 113 to 127=14. Int. 4. R. α.
2. 136 „ 149=13. „ 3. „ β.

Last term uncertain. End at 170.

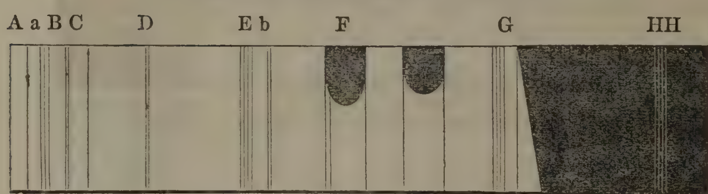


Diagram of Spectrum of Acacia leprosa.

See also Plate II., fig. 1.

Galphinia splendens.

8. *Galphinia splendens.*

1. 113 to 127=14. Int. 5. R. α.
2. 136 „ 155=19. „ 4. „ β.

Questionable third band. End at 191.

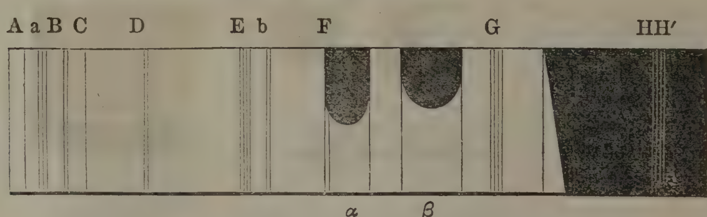


Diagram of Spectrum of Galphinia.

See also Plate II., fig. 2.

Stigmatophyllum ciliatum.

9. *Stigmatophyllum ciliatum.*

1. 115 to 129=14. Int. 4. R. α.
2. 137 „ 159=22. „ 3. „ β.

Questionable third band. End at 191.

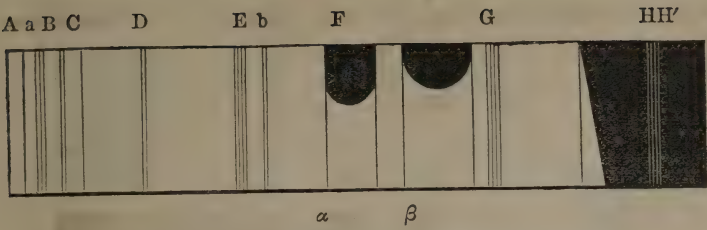


Diagram of Spectrum of Stigmatophyllum.

See also Plate II., fig. 3.

Lankasteria elegans.

10. *Lankasteria elegans.*—Small quantity of dilute solution for examination.

1. 112 to 125.
2. 136 „ 155. Readings uncertain.

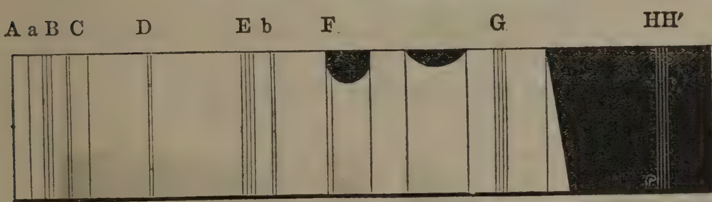


Diagram of Spectrum of Lankasteria flower.

See also Plate II., fig. 4.

Allamanda Neriifolia.

11. *Allamanda Neriifolia.*—Splendid yellow flowers. Solution deep yellow.

1. 112 to 125=13. Int. 5. R. α.
2. 137 „ 157=20. „ 4. „ β.

End at 178.

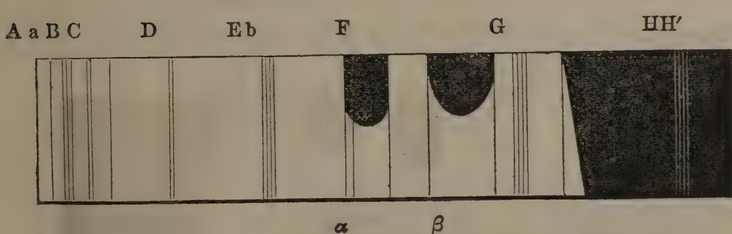


Diagram of Spectrum of Flower of Allamanda.

See also Plate II., fig. 5.

Colutea frutescens.

12. *Colutea frutescens.*—Solution slightly fluorescent.

1. 107 to 119=12. Int. 3. R. α.
2. 128 „ 151=23. „ 2. „ β.

Possible third band. End at 193.

Diagram of Spectrum of Colutea frutescens.

See also Plate II., fig. 6.

Tagetil lucida.

13. *Tagetil lucida.*—Solution slightly fluorescent (?) ; becomes brilliant by heating.

1. 105 to 120=15. Int. 4. R. α.
Cut off at 130.

Diluted + 1 a second band appears.

2. 131 to 145=14, questionable.
End at 158.

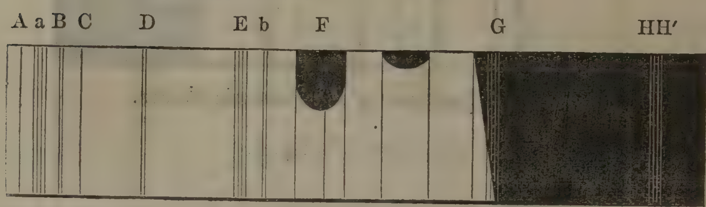


Diagram of Spectrum of Tagetil.

See also Plate II., fig. 7.

Schkuria atrovirens.

14. *Schkuria atrovirens.*—Very pale violet. Absorptions at a minimum.

1. 108 to 123=15. Int. 1.
2. 130 „ 151=21. „ 1.
End at 190.

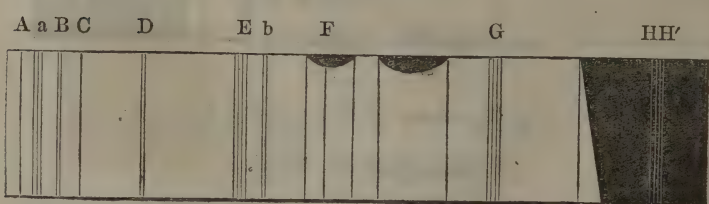


Diagram of Spectrum of Schkuria.

See also Plate II., fig. 8.

Diplotaxis tenuifolia.

15. *Diplotaxis tenuifolia.*—Very pale yellow solution.

1. 113 to 124=11. Int. 2. R. α.
2. 131 „ 148=17. „ 2. „ β.

End at 185.

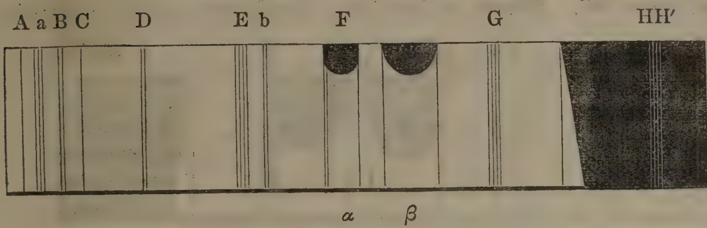


Diagram of Spectrum of Diplotaxis.

See also Plate II., fig. 9.

Virgilia sylvestris.

16. *Virgilia sylvestris.*—Very pale yellow.

1. 114 to 125=11. Int. 3. R. α.
2. 135 „ 153=18. „ 2. „ β.

Questionable third. End at 197.

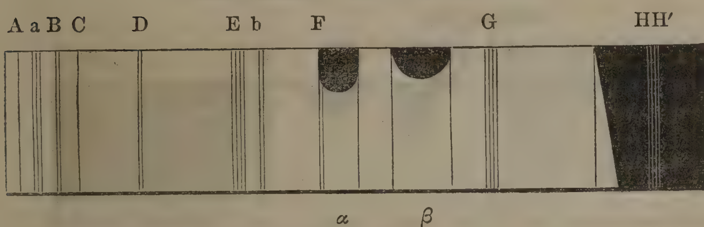


Diagram of Spectrum of Virgilia.

See also Plate II., fig. 10.

Oenothera grandiflora.

17. *Oenothera grandiflora.*

1. 102 to 126=24. Int. 3. R. α.
2. 135 „ 156=21. „ 2. „ β.

End at 178.

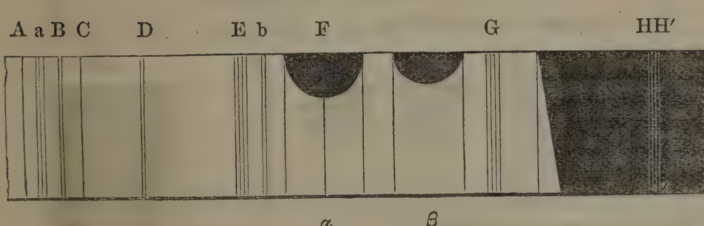


Diagram of Spectrum of Oenothera.

See also Plate III., fig. 1.

Verbascum phlomoides.

18. *Verbascum phlomoides.*—Deep yellow solution. Cut off at 100. Diluted + 1.

1. 112 to 133=21. Int. 6. R. α.
2. 140 „ 163=23. „ 5. „ β.

End about 187. Diluted + 3 at 190. Bands then become very pale.

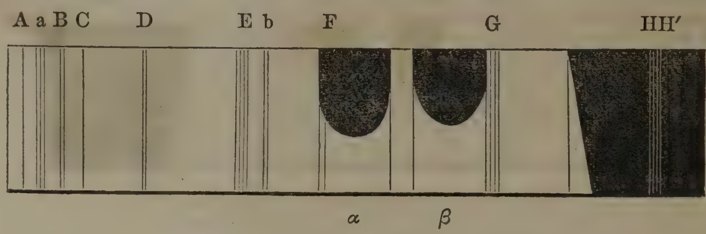


Diagram of Spectrum of Verbascum.

See also Plate III., fig. 2.

Tagetil pumila.

19. *Tagetil pumila.*—Solution turbid.

1. 113 to 125=12. Int. 5. R. α.
2. 133 „ 152=19. „ 2. „ β.

End at 170.

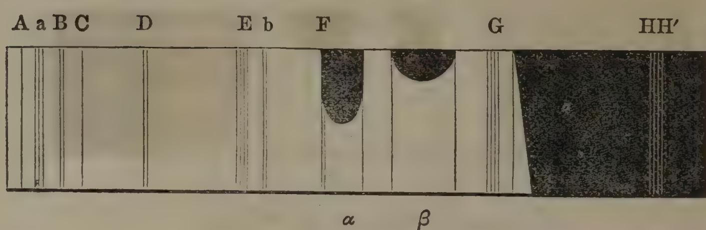


Diagram of Spectrum of Tagetil.

See also Plate III., fig. 3.

Helenium autumnale.

20. *Helenium autumnale.*

1. 107 to 122=15. Int. 5. R. α.
2. 132 „ 152=20. „ 4. „ β.

Dilution produces a suspicion of a third band. End at 190.

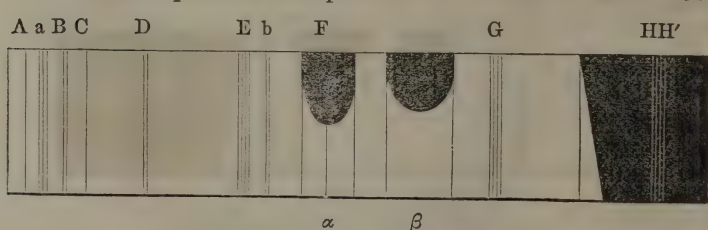


Diagram of Spectrum of Helenium.

See also Plate III., fig. 4.

Linosyris vulgaris.

21. *Linosyris vulgaris.*—Cut off at 108. Diluted + 1.

1. 110 to 125=15. Int. 5. R. α.
2. 135 „ 157=22. „ 3. „ β.

Diluted + 2, suspicion of third band. End at 185.

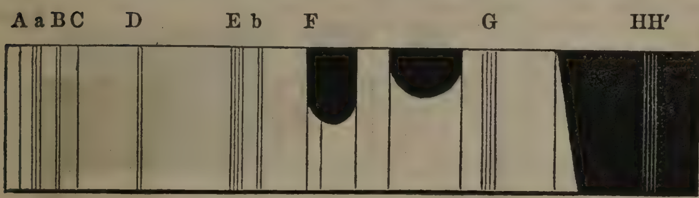


Diagram of Spectrum of Linosyris.

See also Plate III., fig. 5.

Solidago serotina.

22. *Solidago serotina.*—One band appearing diluted + $\frac{1}{2}$.

1. 111 to 124=13. Int. 5. R. α.
2. 134 „ 157=23. „ 3. „ β.

Cut off at 164. Diluted + 3 ends at 185.

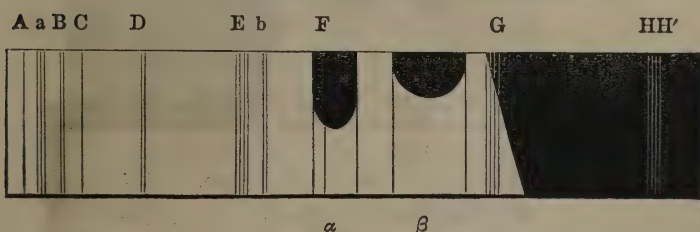


Diagram of Spectrum of Solidago.

See also Plate III., fig. 6.

Ruta graveolens.

23. *Ruta graveolens.*

1. 110 to 125=15. Int. 3. R. α.
2. 133 „ 158=25. „ 3. „ β.

End at 172. Diluted + 1 ends at 185.

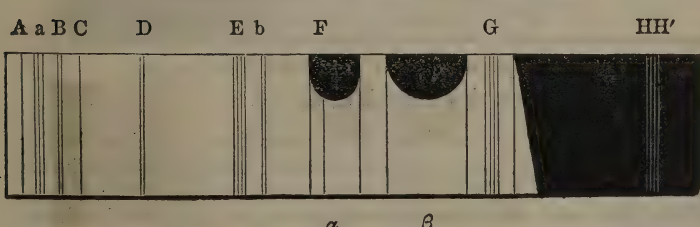


Diagram of Spectrum of Ruta.

See also Plate III., fig. 7.

Melilotus elegans.

24. *Melilotus elegans.*

1. 112 to 125=13. Int. 3. R. α.
2. 135 „ 157=22. „ 2. „ β.

End at 165. Diluted+1 ends at 188.

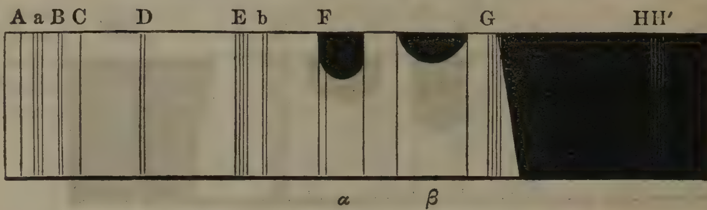


Diagram of Spectrum of Melilotus.

See also Plate III., fig. 8.

Medicago elegans.

25. *Medicago elegans.*—Very dilute solution, layer of 2 ctrs. required.

1. 113 to 126=13. Int. 2. R. α.
2. 135 „ 154=19. „ 2. „ β.

Ends at 163.

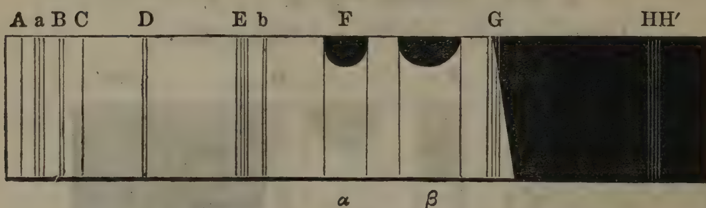


Diagram of Spectrum of Medicago.

See also Plate III., fig. 9.

Allamanda Hendersonii.

26. *Allamanda Hendersonii.*

1. 113 to 125=12. Int. 3. R. α.
2. 134 „ 158=24. „ 4. „ β.

Cut off at 165.

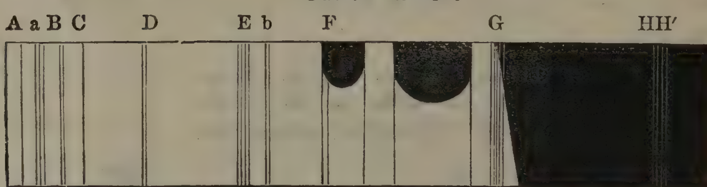


Diagram of Spectrum of Allamanda Hendersonii.

See also Plate III., fig. 10.

Spectra of berries and reeds.

In the foregoing I have described all the varieties of luteine yielding two-band spectra which I have been able to meet with in *flowers* during the month of September 1868. I have ranged amongst them all those in which a third band might have been suspected but could not be shown to exist. In the following I am going to describe a series of two-band spectra from other parts of plants, particularly *berries* and *seeds*.

Asparagus officinalis.

27. *Asparagus officinalis.*—Those who remember the learned essay of the celebrated anatomist Fallopia on the asparagus, will think it fitting that

food for scientific contemplation should be drawn also from the berries of this remarkable plant. The red berries were rubbed with alcohol in a mortar, and the seeds removed. A yellow solution formed, but the red-coloured matter appeared to remain insoluble. The spectrum of this solution was cut off at 115; there was a haze all over the region of blue. The matter was now boiled with water, and after 24 hours filtered. Little coloured matter had dissolved. The red residue was now treated with *warm* alcohol, and yielded all colouring matter easily to the boiling spirit. On cooling a portion of the matter deposited in red flakes. Spectrum of the solution:

1. 110 to 128=18. Int. 3. R. α.
2. 138 „ 156=18. „ 3. „ β.

Possible third band. End at 195.

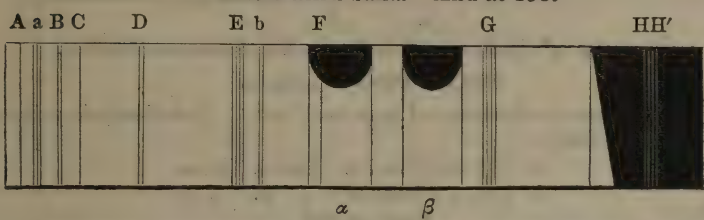


Diagram of Spectrum of Asparagus Berries.

Compare also Plate IV., fig. 1.

28. *Physalis Alkekengii.*—The husk of the berry is a wide red bag. Physalis Alkekengii.

1. 104 to 120 =16. Int. 3. R. α.
2. 129 „ uncertain=18. „ 1. „ β.

Solution 2 ctrs. thick. No bands in layer of ctr.

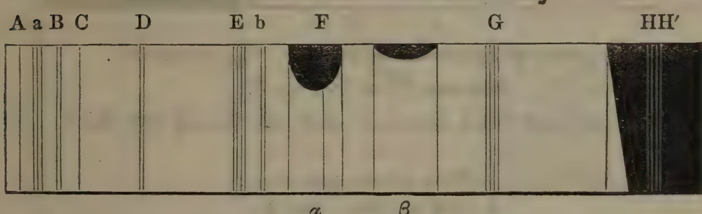


Diagram of Spectrum of Husk of Physalis Berry.

See also Plate IV., fig. 2.

29. *Solanum Dulcamara Berries.*—Solution saturated yellow to orange. Solanum Dulcamara.

1. 107 to 122=15. Int. 2. R. α.
2. 128 „ 151=23. „ 2. „ β.

Suspected third. End at 190.

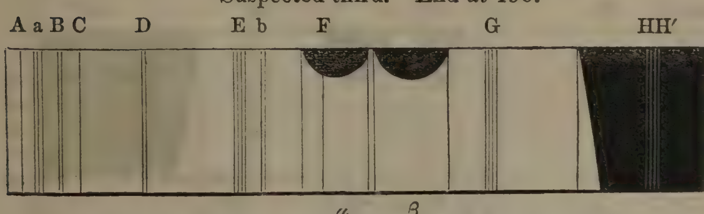


Diagram of Spectrum of Solanum Dulcamara Berries.

Compare Plate IV., fig. 3.

Solanum capsicastrum.

30. *Solanum Capsicastrum Berries.*—Pale yellow solution. *Fluoresces distinctly*, and in that respect is the only yellow substance showing detached bands which I have met with.

1. 106 to 120. Very pale } Solution 3 ctrs.
2. 130 „ 149. do. } thick.

Ends at 188.

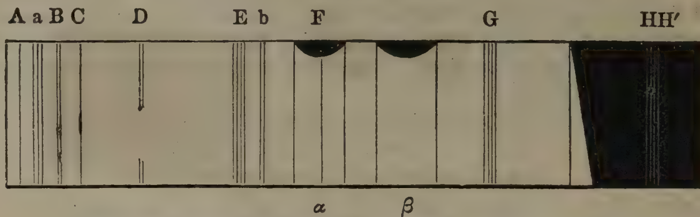


Diagram of Spectrum of Solanum Capsicastrum Berries.

See also Plate IV., fig. 4.

Cyphomandra betacea.

31. *Cyphomandra betacea.*—Large oval berry. Solution pale yellow. Layer 3 ctrs. thick.

1. 103 to 114=11. Int. 3. R. α.
2. 125 „ 145=20. „ 2. „ β.

Ends at 163.

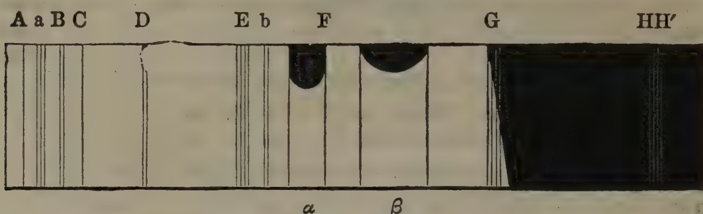


Diagram of Spectrum of Berry of Cyphomandra.

See also Plate IV. fig. 5.

Cratægus cnut Galli.

32. *Cratægus cnut Galli Berries.*—Red solution $2\frac{1}{2}$ ctrs. thick. Cut off at 97.

1 ctr. thick pale yellow, shows spectrum:

1. 102 to 114. Int. 1.
2. 124 „ 142, „ 1.

Ends at 180.

2 ctrs. thick it shows spectrum:

1. 100 to 116 = 16. Int. 4. R. α.
2. 124 „ 148 = 24. „ 3. „ β.

Ends at 160.

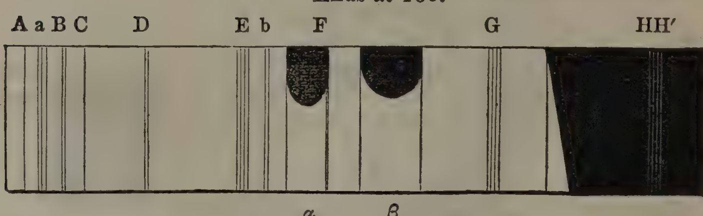


Diagram of Spectrum of Berries of Cratægus.

See also Plate IV., fig. 6.

Pyrus Aria.

33. *Pyrus Aria Berries.*—Yellow solution, 2 ctrs. thick.

1. 103 to 118 = 15. Int. 4. R. α.
2. 126 „ 147 = 21. „ 3. „ β.

Ends at 163.

With a layer of 1 ctr. thick bands disappear and end at 190.

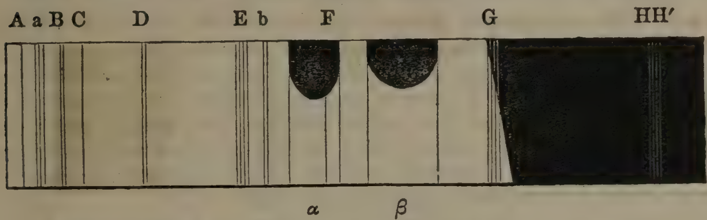


Diagram of Spectrum of Berries of Pyrus Aria.

See also Plate IV., fig. 7.

Zea Mais.

34. *Zea Mais or Indian Corn;* Seeds.—The powdered seeds treated with warm alcohol yielded a golden yellow solution which became turbid on cooling; it shed a deposit on standing and then was clear. The very concentrated solution showed red and yellow, and was cut off at 105. First probable band on slight dilution, 105 to 123. More dilute solution, 1. 107 to 118; 2. 128 to uncertain. A more clear but more dilute solution 2 ctrs. thick showed, 1. 107 to 118; 2. 128 to 147. Ultimately the following measurements were adopted as final:

1. 108 to 122 = 14. Int. 2. R. α.
2. 128 „ 148 = 20. „ 2. „ β.

Last line difficult to read and somewhat doubtful.

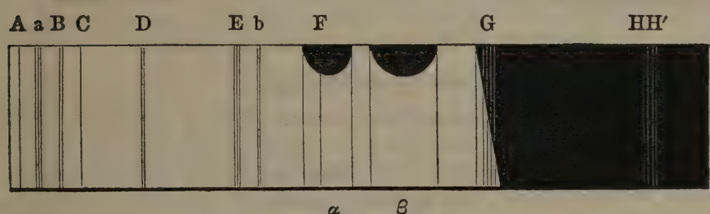


Diagram of Spectrum of Maize Seeds.

See also Plate IV., fig. 8.

These bands, therefore, are the same almost as those of the alcohol solution of ovario-luteine, which read—

1. 107 to 120.
2. 128 „ 149.

There is a matter contained in the extract of the seeds which absorbs entirely the violet end where a third band might possibly appear, and does appear in the animal, and some vegetable luteine solutions.

d.

Three-banded Luteine Spectra.

Three-banded luteine spectra.

I pass now to a series of vegetable spectra which most closely resemble the spectra of animal luteine already described. In some of them the

third band is less distinct than in the animal luteines, in others it is more distinct, and the whole of the three-banded spectra have therefore on plate IV., fig. 9 and 10, plate V., fig. 1 to 10, and plate VI., fig. 1 to 3, been arranged in accordance with this progression of distinctness.

Common carrot, Carotine.

Daucus carrota, Common carrot-root.—The colour of the carrot is due to a particular matter termed *carotine*, $C_{18} H_{24} O$. It is reddish-brown in crystals, crystallises in cubes, smells like the Florentine violet-root, and with concentrated sulphuric acid becomes blue, and dissolves with the same colour. However similar, therefore, the spectrum of carotine may be to that of the animal luteines, its chemical properties seem to be different. Carotine heated to 150 becomes reddish-brown, and in that state is the substance to which so-called cichory, or chicory, owes its tinctorial qualities and fraudulent use.

Some carrots were scraped and extracted with warm alcohol. The yellow solution on cooling became opaque and was again filtered.

1. 103 to 120 = 17. Int. 5. R. α.
2. 128 „ 149 = 21. „ 5. „ β.

End at 160. Dilution + 1 extended violet to 197, and there appeared a feeble band.

3. 165 to 180 = 25. feeble 5 R. γ.

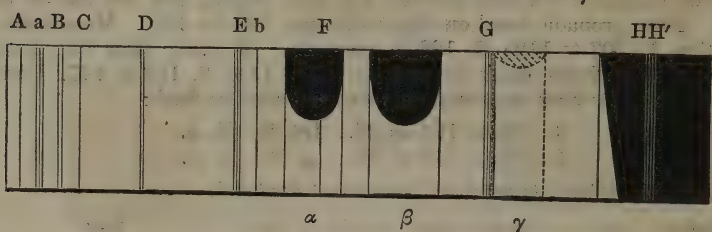


Diagram of Spectrum of Common Carrot.

See also Plate IV., fig. 9.

Bixa orellana, or Annatto.

Annatto, or *Orlean*, the flesh of the fruit of *Bixa orellana*, a South American tree. It occurs in trade as a plastic red paste. It contains perhaps two colouring matters, of which *orelline* is the least characterised. *Bixine* is the main dyeing ingredient; it is little soluble in water, easily in alcohol and ether, with orange colour. Concentrated sulphuric acid colours it *blue*, next *violet;* nitric acid changes it to green, ultimately yellow. A concentrated alcohol solution of orange colour cut the spectrum off at 77. On dilution the absorption gradually receded towards 89, further to 92. When more diluted, so that the solution was yellow, absorption receded to 103. Again diluted to light yellow, a spectrum of bands appeared :

1. 105 to 121 = 16. Int. 5. R. α.
2. 132 „ 148 = 16. „ 4. „ β.
3. 167 „ 178 = questionable.

Blue to 203.

At a particular dilution, with strongest Drummond's light I measured finally—

1. 106 to 124 = 18. Int. 5. R. α.
2. 129 „ 153 = 24. „ 5. „ β.
3. 162 „ 181 = 19. „ 1. „ γ.

End at 205.

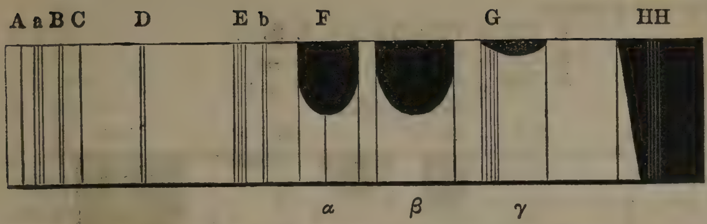


Diagram of Spectrum of Annatto, or Bixine.
See also Plate IV., fig. 10.

Annatto is used for dyeing silk. Most English cheese is dyed with annatto and turmeric.

Calendula officinalis, Common Marigold.—The cold alcoholic extract has a splendid yellow colour. Like the extract of calceolaria, the concentrated solution cuts the spectrum off at blue. Diluted there appears— Calendula, Marigold.

1. 109 to 123 = 14. Int. 3. R. γ. Sharply cut off at 127. On dilution second band appears, which has now treble the strength of the first, which latter becomes int. 2.

2. 129 to 146 = 17. Int. 5. R. α.
3. 156 „ 177 = 21. „ 5. „ β.

End at 189.

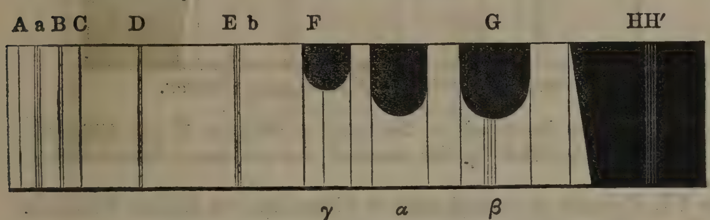


Diagram of Spectrum of Flower of Marigold.

Again diluted band 1 almost disappears, and 2 and 3 remain of int. 2. In this spectrum the three bands are most distinct, but the distribution of intensity is most peculiar.

Chrysopsis villosa. Chrysopsis villosa.

1. 109 to 120=11. Int. 8. R. α.
2. 131 „ 154=23. „ 5. „ β.

Diluted + 1 there appears—

3. 167 to 183=16. „ 1. „ γ.

End at 200.

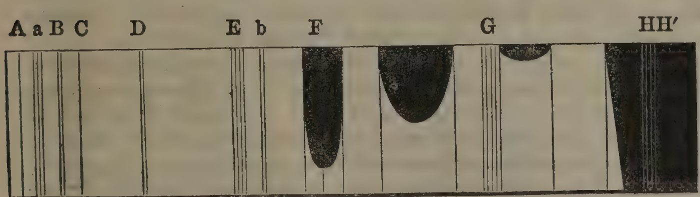


Diagram of Spectrum of Chrysopsis Flower.

Obliscaria pinnata.

Obliscaria pinnata.

1. 108 to 122=14. Int. 4. R. α.
2. 131 „ 154=23. „ 3. „ β.
3. 165 „ 185=20. „ 1. „ γ.

End at 193.

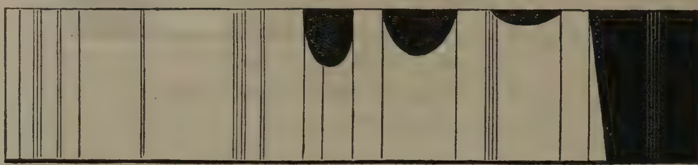


Diagram of Spectrum of Obliscaria.

Heliopsis lævis.

Heliopsis lævis.

1. 107 to 124=17. Int. 5. R. α.
2. 131 „ 155=24. „ 3. „ β.

Diluted + $\frac{1}{2}$.

3. 164 „ 182=22. „ 1. „ γ.

End at 192.

Diagram of Spectrum of Heliopsis Flower.

Plate I. to V. are described in the text of chapter N, pp. 183–216; each spectrum is identified by the name of the substance from which it is derived.

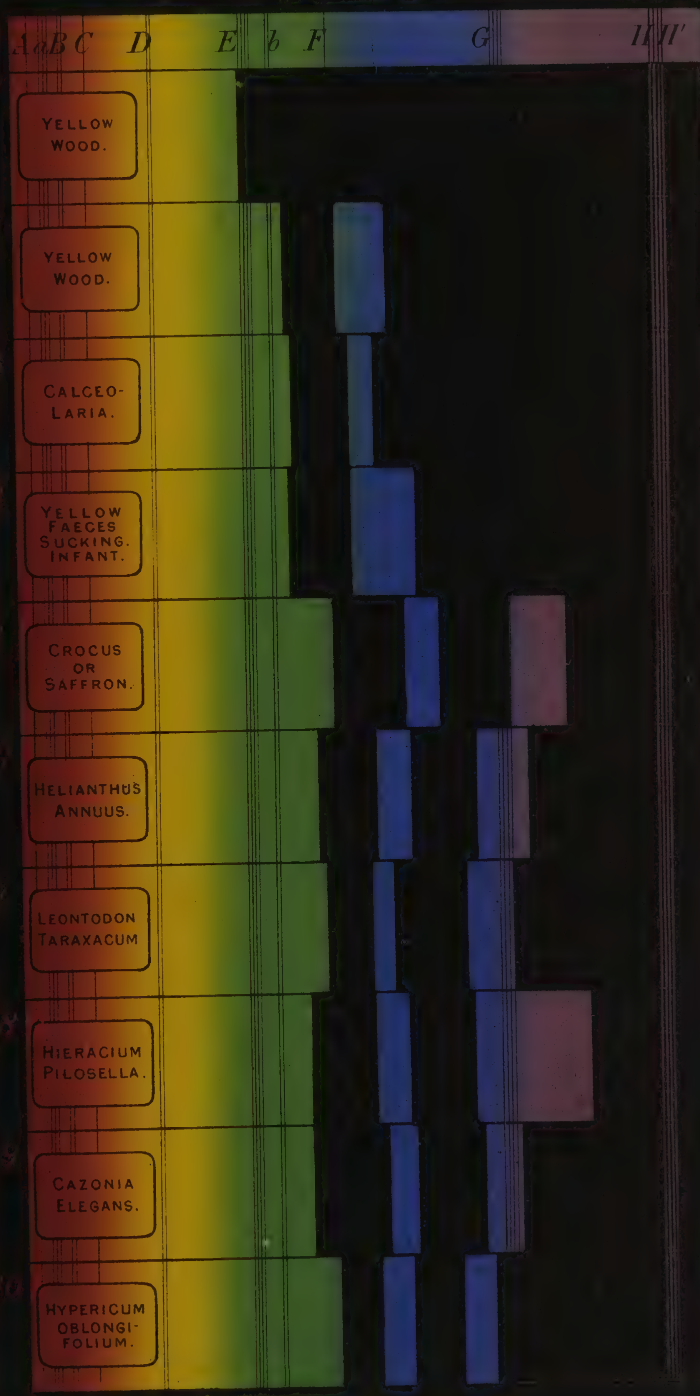
Plate VI. Crystals of cholophaeine or bilirubine (see Eighth Report of the Medical Officer, 1868).

Plate VII. Crystals of ovario-luteine.

Plate VIII. The measurements of spectra in the cholera report 1867, were given in minutes and degrees of a quadrant of the disk of the spectrometer. After the construction of the new spectrometer and observatory, described in the report for 1868, I adopted a more convenient scale of 245 divisions, of which 20 project into the caloric region, and 25 into the fluorescent or metachromatic region, while 200 were made to divide equally the visible chromatic spectrum, the line 60 being made to coincide with the middle of the D line. This scale is represented on the left of the explanatory drawing (plate viii); on the right is given the scale of 1867, and between both are the principal sun-lines in the accurate position in which they would be indicated by either scale. All spectra in my three reports are of the same standard length with reference to the sun-lines, and consequently can be expressed in points of either scale. One scale can be easily transformed into the other empirically, by means of a pair of compasses on the explanatory drawing of plate viii.

The indications of any scale whatever can be transformed into the corresponding ones of any other by the method of Steinheil. The two scales are united at their zero point at a right angle, and a diagonal is erected in the angle between them, the position of which is determined by the point of section of two perpendicular lines erected on two corresponding points, say D and D′. The corresponding points of each scale are then determined by the points in the diagonal in which any two perpendiculars from the scales cut each other. (For particulars and drawings, see Carl, Repert. f. physik. Technik, vol. 1, p. 85, and Atlas plate xi.g. 10 and 11.)

Plate I.



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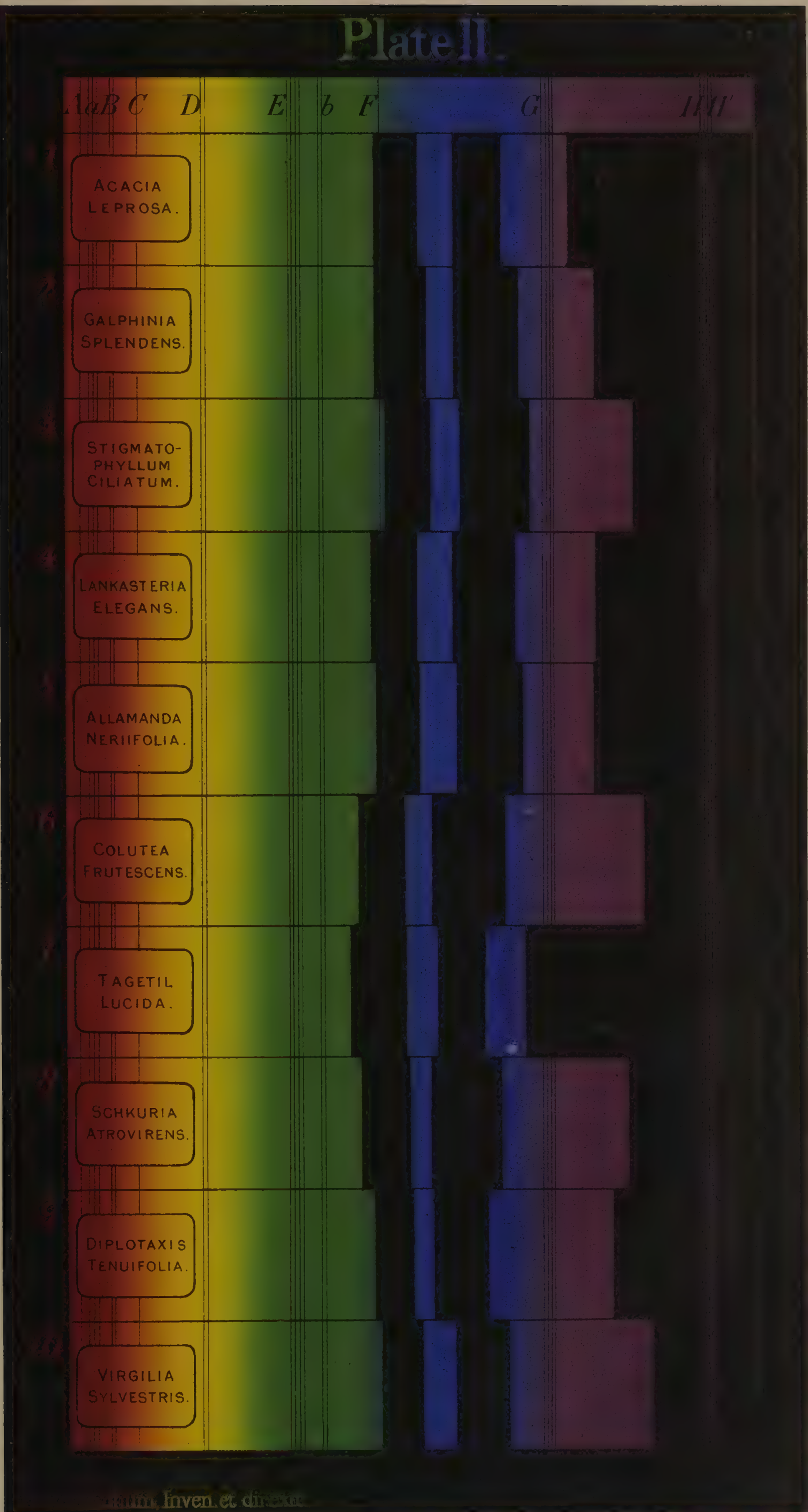

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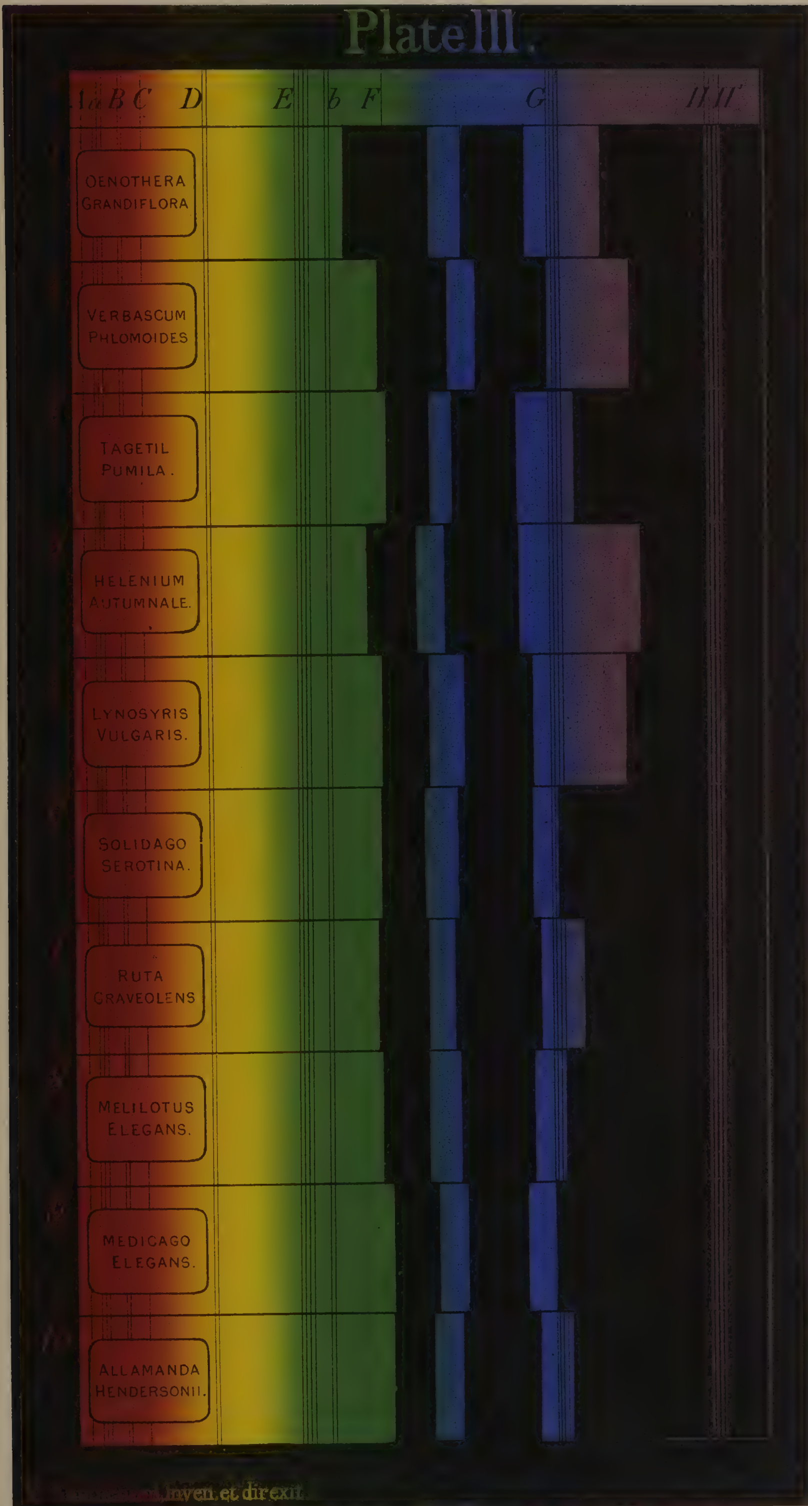

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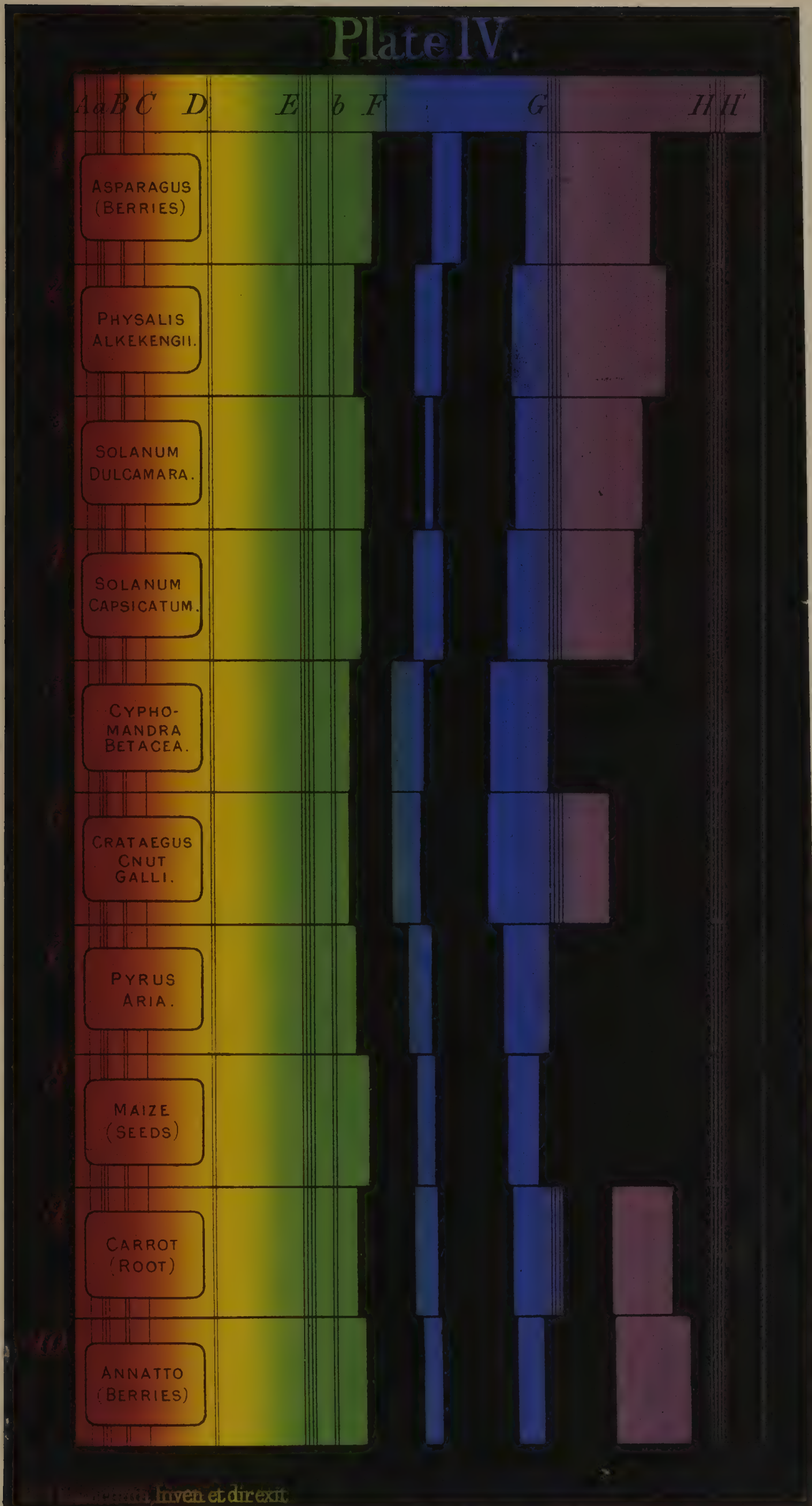

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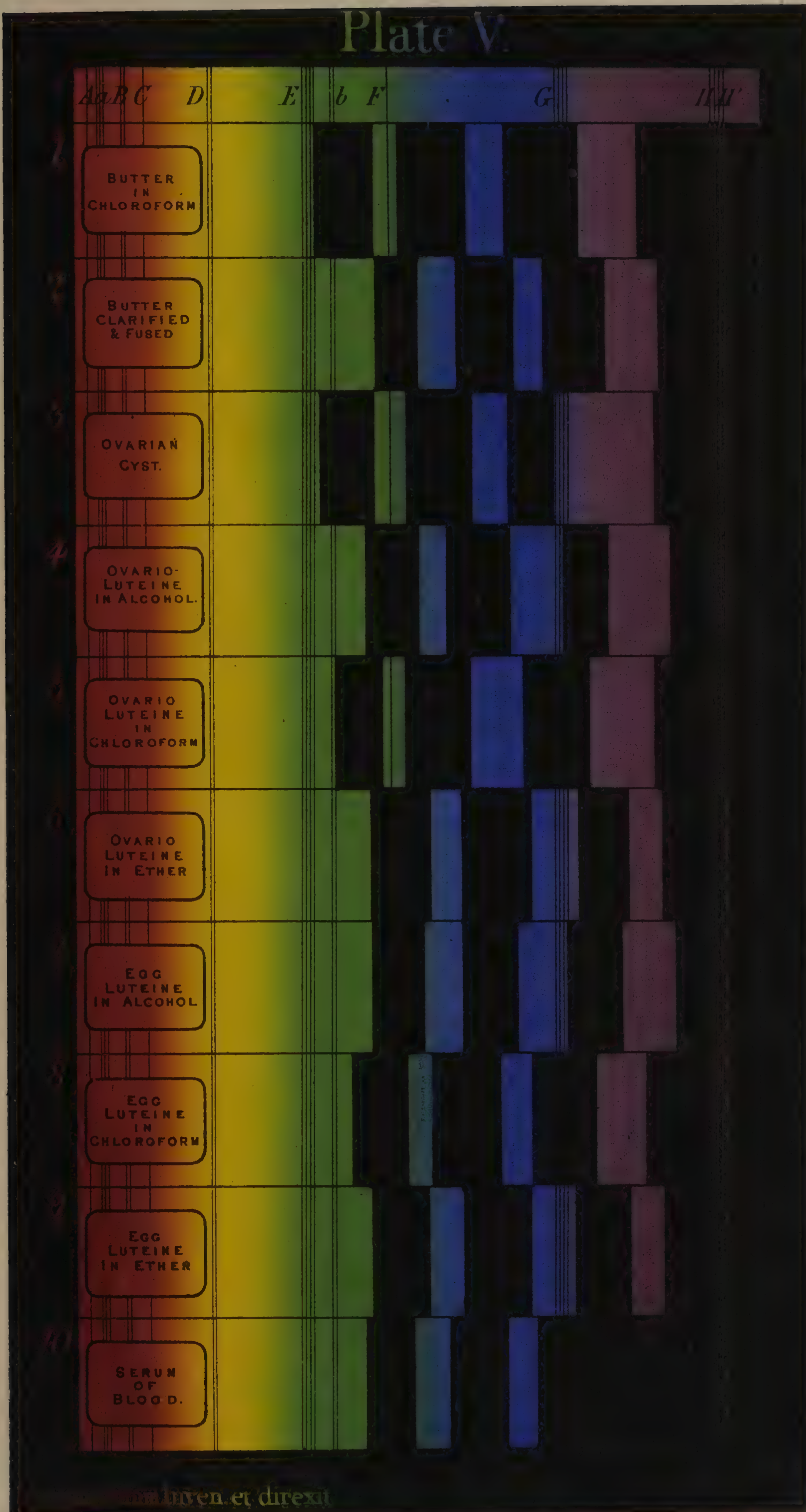

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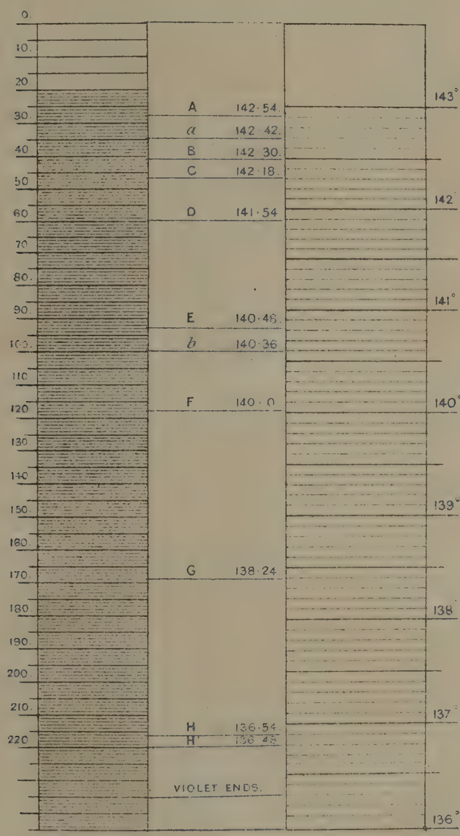
Dr Thudichum Inven. et Direxit _ J. Buckley, Pinxit

Vincent Brooks Day & Son Lith

Dr Thudichum Inven. et Direxit. J. Buckley, Pinxit. Vincent Brooks Day & Son, lith.

COMPARISON OF FORMER AND PRESENT SPECTRO-SCOPICAL SCALES.



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